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The effects of frequency of strength training in prepubescent girls

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THE EFFECTS OF FREQUENCY OF STRENGTH TRAINING IN PREPUBESCENT GIRLS

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ABSTRACT

THE EFFECTS OF FREQUENCY OF STRENGTH TRAINING IN PREPUBESCENT GIRLS

by Analisa F. Naldi

This study investigated the muscular strength effects of training twice per week versus once per week, with the same training volume. Twenty-six girls ages, 7-11, participated in 10 weeks of strength training. Group one trained 1 day per week and group two trained on 2 nonconsecutive days per week. Strength changes were statistically evaluated by comparing 1RM values using a 2-way (group x time) mixed-analysis of variance (ANOVA) with repeated measures on the time variable. There was a significant effect for time, indicating both groups experienced significant strength gains during the training program. Both the back squat and supine bench press results showed greater strength gains during the first 7 weeks versus the latter 3 weeks of training. These findings support the concept that muscular strength can be improved during childhood working out either once or twice per week in a beginning strength training program.

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Chapter 1

Introduction

A 2001 survey by the Sporting Goods Manufacturers Association reported approximately 26.6 million youth (ages 6-17) play on an organized sports team with another 10 million that reported playing at least one team sport, but not as a member of an organized team. Youth participation in competitive team and individual sports has nearly doubled since 1971. By 2005, boy's and girl's participation had risen to 4,110,319 and 2,908,390 respectively (National Federation of State High School Associations (NFHS), 2005). Payne and Isaacs (2005) suggest possible explanations for the rise in opportunities to participate at younger ages. An increase in female participation due to 1972 passage of Title IX, an increase in participation in non-traditional sports (NFHS, 2005), and increased opportunities for disabled youth are named as contributors to the increase in youth sports participation. Additionally, with parents recognizing the general health, academic, and social benefits to sports participation, opportunities for youth in sport continue to grow.

Although youth participation in sport has increased, the Surgeon General states that nearly half of American youths between the ages 12-21 report not being physically active on a regular basis, and daily enrollment in physical education classes dropped nearly 17% between 1991-1995 (2000). It has been shown that obesity in children ages 6-11 years old has increased from 4.2% in 1963-1965 to 18.8% in 2003-2004 (National Center for Health Statistics, 2004). What happens to those children that are not able to participate in sport outside of school? Due to physical education classes being reduced, children and their parents are seeking alternative methods to increase physical activity levels and improve performance. The support and acceptance of youth strength training in prepubescents and adolescents has increased as demonstrated by publications from a number of professional organizations (American Academy of Pediatrics, 2001; American College of Sports Medicine, 1995; Faigenbaum et al., 1996). Strength training has been recognized as a safe, effective part of youth physical activity programs, sports, and injury prevention strategies.

Since strength training has been found to be beneficial in children and adolescents, researchers have dedicated time to establishing the most effective methods of training. Research has determined that prepubescent and adolescent males and females can increase muscular strength and muscular endurance levels as a result of a strength training program (Faigenbaum et al., 1993; Faigenbaum et al., 1996b; Faigenbaum, Milliken, & Westcott, 2003; Flanagan et al., 2002; Fukunaga, Funato, & Ikegawa, 1992; Gallagher & DeLorme, 1949; McGovern, 1983; Mersch & Stoboy, 1989; Ozmun et al., 1993; Pfeiffer & Francis, 1986; Ramsay et al., 1990; Rians et al., 1987; Russell, 1991; Servedio, 1984; Sewall & Micheli, 1986; Sothern et al., 2000; Weltman et al., 1986).

Pfeiffer and Francis (1986) compared the effects of resistance exercise on 80 prepubescent, pubescent, and adolescent males. Following 9 weeks of progressive overload circuit training, the training group showed significant increases in both upper and lower body strength. Strength increases were found to be significant across all three maturity levels. In 1986, Sewall and Micheli compared the responses of prepubescent children strength training to an age-matched control group. All three of the muscle groups that were specifically targeted by the training program showed significant increases in strength. An overall increase in strength of more than 40% was noted during the 9-week training period. Faigenbaum et al. (1993) evaluated the effects of a short-term twice-a-week strength training program on boys and girls between ages 8 and 12. Significant strength gains were found in both the upper and lower body. These results indicated that strength gains can be attained training twice per week in a progressive training program. Faigenbaum et al. (1996b) evaluated the effects of strength training and detraining on 24 healthy, untrained boys and girl, ages 7-12. The training group demonstrated significant strength gains during the 8 week training phase, with greater gains being recorded during the latter 4 weeks of training. By testing the effects of training and detraining, Faigenbaum et al. (1996b) were able to show that strength gains are attainable and reversible. Although the research has shown that prepubescents and adolescents can significantly increase strength levels provided that the program is designed prescribing the appropriate duration and intensity, optimal training conditions have yet to be determined. Therefore, further research is needed to determine optimal training volume and intensity.

Total training volume (repetitions x sets) is the total number of repetitions completed during one workout session (Pauletto, 1985). Little research has been conducted on the effects of training volume on strength gains in prepubescents and adolescents. Faigenbaum et al. (1999) compared the responses of a low-repetition, heavy-load training program to a high-repetition, moderate-load training program in children. The high repetition group showed significantly greater strength gains compared to the low repetition group. Faigenbaum et al. concluded that muscular strength can be improved during childhood utilizing a high repetition-moderate load resistance training program during the initial training period. Continuing the investigation on training volume, Faigenbaum et al. (2002) compared once per week and twice per week progressive strength training programs on total body strength and motor performance ability in children. Faigenbaum et al. (2002) concluded "...strength gains were significantly greater in those that trained twice per week..." (p.422). Faigenbaum et al. included that greater strength gains in the twice per week group could have been due to the training volume being double that of the once per week training group. In the same study, the authors commented "...that higher training volumes have been recommended as providing a better training stimulus for children," (p. 421). Therefore if the training volume were similar for both training frequencies, the differences in strength gains between the two training groups would not be as significantly different.

Previous studies focused on the investigations of young boys (Mero et al., 1988; Mersch & Stoboy, 1989; Pfeiffer, & Francis, 1986; Ramsay et al., 1990; Servedio, 1984; Weltman et al., 1986), the combination of boys and girls together (Faigenbaum, LaRosa Loud, 2001), or comparing the differences between boys and girls (Siegel et al., 1989). Of the articles reviewed for the present study, 15 studies used boy and girl subjects. Siegel et al. was the only study to report boy's and girl's data separately. Seigel et al. reported that there were no significant differences between strength gains of boys versus girls. Of the remaining articles reviewed for the present study, 15 used boy subjects, and one study used only female subjects. Nielsen, Nielsen, Behrendt Hansen, and Asmussen, (1980) tested isometric strength in knee extension, and functional muscular strength. The participants were females between the ages of 7-19 years old. The need for further research on females is discussed by Payne, Morrow Jr., Johnson, and Dalton, (1997) stating that of the 179 effect sizes they used in their meta-analysis, only 23 were from female participants. The need for more research on the issues surrounding strength training in young girls is great in order to fully understand how strength training affects prepubescent girls.

Therefore, the purpose of this study was to examine the effects of a twice per week training program versus a once per week training program, designed with the same training volume, in prepubescent girls.

Statement of Problem

There is research supporting the potential strength gains due to implementation of a strength training program in prepubescent children and adolescents (Faigenbaum et al., 1993; Faigenbaum et al., 1996b; Faigenbaum, Milliken, & Westcott, 2003; Flanagan et al., 2002; Fukunaga, Funato, & Ikegawa, 1992; Gallagher & DeLorme, 1949; McGovern, 1983; Mersch & Stoboy, 1989; Ozmun et al., 1993; Pfeiffer & Francis, 1986; Ramsay et al., 1990; Rians et al., 1987; Russell, 1991; Servedio, 1984; Sewall & Micheli, 1986; Sothern et al., 2000; Weltman et al., 1986), but a lack of research that focuses specifically on prepubescent girls (Nielsen, Nielsen, Behrendt Hansen, & Asmussen, 1980; Payne, Morrow Jr., Johnson, & Dalton, 1997). There is, however, a lack of research investigating the effects of training frequency on strength gains in the youth population (Faigenbaum et al., 2002). Thus, there is a need for more research to address the issue of frequency of specific strength training programs in order to identify if the benefits of these programs is different (Faigenbaum et al., 1993; Faigenbaum et al., 2002).

Beyond the lack of research on frequency of specific strength training programs, it is important to obtain scientific evidence indicating the effects of strength training on prepubescent girls because the number of girls participating in both team and individual sports in increasing (NFHS, 2005). If girls are becoming more active and participating in more sports, it is important for them to understand the benefits of strength training, injury prevention, and strength gains. In order to properly administer a strength training program that will address the specific goals of each prepubescent girl, a complete understanding of the effects must be had.

Statement of Purpose

To address the problem of a lack of research on the effects of training frequency on strength gains in prepubescent girls, a 10-week strength training program was implemented with one training group that completed one strength training session per week, while the other training group completed two strength training sessions per week. The total training volume (repetitions x sets) was the same for the two groups. This study provided information regarding the direct effects of training frequency on prepubescent girls and will be beneficial for coaches and parents in that it will enable them to implement a strength training program in the lives of their young female children.

Null Hypotheses

1) There will be no statistically significant difference between 1RM values for the once per week and twice per week training groups for each lift.

2) There will be no statistically significant difference between 1RM values pre-training and week 4 in the back squat and the supine chest press.

3) There will be no statistically significant difference between 1RM values at week 4 and week 7 in the back squat and the supine chest press.

4) There will be no statistically significant difference between 1RM values at week 7 and post-training in the back squat and the supine chest press.

5) There will be no statistically significant difference between 1RM values pre-training and post-training for the dead lift.

6) There will be no statistically significant difference between 1RM values pre-training and post-training for the seated row.

7) There will be no statistically significant difference between 1RM values pre-training and post-training for the seated dumbbell curl.

8) There will be no statistically significant difference between 1RM values pre-training and post-training for the standing military press.

9) There will be no statistically significant difference between 1RM values pre-training and post-training for the seated calf raise.

Operational Definitions:

1) Untrained: Having no history of participation in any structured strength training within the 2 months preceding the study (Baechle & Earle, 2000, p. 397).

2) Volume: Total number of repetitions completed during one workout session (Pauletto, 1985, p. 67).

Definitions:

1) One Repetition Maximum (1RM): The 1RM was defined as the "...maximal resistance that can be lifted throughout the full range of motion (determined in the unweighted position) using good form once," (Faigenbaum, Milliken, & Westcott, 2003, p. 163).

2) Resistance Exercise: "...a specialized method of conditioning that involves the progressive use of resistance to increase one's ability to exert or resist force," (Baechle & Earle, 2000, p.170).

3) Repetitions: "...the number of times an exercise is done without resting during one set," (Pauletto, 1985, p. 67).

4) Set: "...group of repetitions sequentially performed before the participant stops to rest" (Baechle & Earle, 2000, p. 417-418).

5) Strength: "...maximal amount of force that a muscle or muscle group can generate at a specified velocity" (Baechle & Earle, 2000, p. 35)

Limitations:

The results of this study were limited by the following:

1) The results may not be applicable to adolescent and adult males and females.

2) There was no random selection, only random assignment to groups.

3) The results may not be applicable to male pre-pubescents.

4) The results may not be applicable to populations in other geographic regions.

5) The results may not be applicable to individuals with injuries or disabilities.

6) All participants may not have given their maximal effort during pre- and post-testing procedures.

7) There was an uneven amount of time between the 1RM testing pre-training and week 4, and week 7 to post-training, when compared to the conclusion of week 4 and week 7.

8) Participants were allowed to continue participation in non-strength training recreational and team sporting activities.

Delimitations:

This study was delimited to the following:

1) A sample population of 26, 7-11 year old, female subjects from the metropolitan area in and around San Jose, CA.

2) Participants who were allowed to participate after receiving a healthy clearance from their local family/primary care physician.

3) Participants who were allowed to participate only after receiving parental or guardian informed consent.

Assumptions:

The following assumptions were made:

1) The participants did not perform any additional strength training outside of that directly related to this research study.

2) All participants were sufficiently motivated to complete their strength training programs to the best of their abilities.

3) All participants followed instructions to the best of their ability in performing the tasks in their respective strength training programs.

Summary:

America's young females are actively participating in sport, as proven by their participation statistics more than quadrupling in the last 30 years (NFHS, 2005). As participation increases, so does the need to create stronger, healthier female athletes. Strength training has been shown to improve the muscular strength levels of both young males and females, but with significantly more data supporting the gains in males (Faigenbaum et al., 1993; Faigenbaum et al., 1996b; Faigenbaum, Milliken, & Westcott, 2003; Flanagan et al., 2002; Fukunaga, Funato, & Ikegawa, 1992; Gallagher & DeLorme, 1949; McGovern, 1983; Mersch & Stoboy, 1989; Ozmun et al., 1993; Pfeiffer & Francis, 1986; Ramsay et al., 1990; Rians et al., 1987; Russell, 1991; Servedio, 1984; Sewall & Micheli, 1986; Sothern et al., 2000; Weltman et al., 1986), but a lack of research that focuses specifically on prepubescent girls (Nielsen, Nielsen, Behrendt Hansen, & Asmussen, 1980; Payne, Morrow Jr., Johnson, & Dalton, 1997). Frequency of training has been investigated and found to be more beneficial when training sessions occur at least 2 times per week (Faigenbaum et al, 1993; Faigenbaum et al., 2002). However, high training volumes are possible in a once per week training program, but have never been tested in children. Due to the fact that there are a limited number of strength training studies with female participants (Falk, & Tenenbaum, 1996; Payne, Morrow Jr., Johnson, & Dalton, 1997), the necessity to investigate this participant population is increasing. The intent of this study was to combine the need for young female-based strength training studies with the effects of training frequency with a similar training volume.

Chapter 2

Review of Literature

The following section reviews the research that investigated the following: responses to resistance training programs in children and adolescents, resistance training volume investigations in children and adolescents, and prepubescent, pubescent, and adolescent female resistance training investigations. The following literature review includes studies that utilized progressive overload training, circuit training, Olympic-style weight training, isometric, and isokinetic training designs. The literature review also details the investigations on the effects that training volume has on the responses to resistance training within the youth population. Finally, the literature review provides evidence that there is sufficient scientific research supporting the strength gains attainable in prepubescent and adolescent boys, with fewer studies demonstrating the strength gains possible in young girls.

Investigations of Child and Adolescent Responses to Resistance Training Programs

The following section includes studies that investigated the physiological responses of children and adolescents to various types of resistance training program designs. The program designs included progressive overload in circuit training, hydraulic-resistance, and an Olympic-style lifting format. Body-weight based exercises, isotonic training methods, and unconventional strength training modalities (ie. Medicine balls) were also implemented in various investigations.

Gallagher and DeLorme (1949) investigated the technique of progressive resistance exercise for adolescents. Using knee injuries and lower back injuries as motivation for their study, they documented injuries and rehabilitation programs with a progressive design. Five knee injury cases were documented in which adolescent subjects used the leg press and leg extension exercise as part of their progressive training regimen. In each case, the strength in the quadriceps and hamstrings was improved, as well as the resistance greatly increased over time. Similar results were reported for those cases involving low back injuries, with improvements in back extensor strength. Gallagher and DeLorme concluded that the method was valuable in a physical therapy environment, as well as a strength training environment, providing that programs were individualized, appropriately supervised, and well documented.

Circuit training has also been studied. McGovern (1983) employed a 12-week, structured, circuit weight training program with middle school children. The participants were randomly assigned to a training group or a control group, within their selected age groups (3rd grade, 5th grade). Children in the training group completed a strength training program three days per week. The training program consisted of two different 10-station circuits, consisting of a combination of Universal and Paramount equipment. Participants completed exercises targeted at the quadriceps, hamstrings, gluteals, abdominals, latissimus dorsi, pectorals, biceps, deltoids, and triceps. After 12 weeks of training, the training group demonstrated a significant increase in strength, with strength gains equally true across age groups. McGovern concluded that strength gains in children are significant when a circuit training strength program design is utilized.

Servedio (1984) explored the effects of eight weeks of strength training on pre-pubescent boys using Olympic-style lifts. The Olympic-style lifts included were the clean, the jerk, and the snatch. The participants were assigned to either the training group or the control group. The control group was asked not to participate in any strength training for the duration of the study. Training three times per week, the boys in the training group were instructed on how to properly perform the necessary Olympic lifts. Once they could replicate the motion, they progressed to a barbell with no added resistance. When the coach observed that they were ready to progress, they performed their first maximal lift. During the entire training period, the participants were tested for improvements on their maximal lifts two other times. The participants performed six to eight sets of two to four repetitions with loads varying from 30% to 80% of their maximum. The strength gains in the training group were greater than those that occurred in the control group. Results indicated that pre-pubescent boys can safely perform Olympic-style weight training exercises as well as increase personal strength levels.

Pfeiffer and Francis (1986) compared the effects of resistance exercise on prepubescent, pubescent, and adolescent males. Their study included 80 healthy, untrained males between the ages of 8 and 21. The three maturity groups within the experiment (pre-pubescent, pubescent, adolescent), were separated by random assignment into training groups or control groups. Subjects in the control groups were asked not to complete any strength or weight training for the duration of the study. Initial isokinetic strength data were collected for elbow and knee flexors and extensors on the right side of the body. The strength testing consisted of a short warm-up, followed by three trials at a velocity of approximately 30 degrees per second. After several minutes of rest, three more trials at a velocity of approximately 120 degrees per second were conducted. The peak torque values at both speeds were recorded for each subject. A progressive strength training program with four primary exercises (leg extension, leg curl, bench press, bicep curl) was implemented by each training group. Each subject was required to complete three sets of 10 repetitions at 50%, 75% and 100% of 10RM, respectively, during each training session. Subjects were asked to complete one additional set of an ancillary exercise per workout. The ancillary workouts were rowing, shoulder extension, leg press, sit-ups, and chest flies. The groups rotated around the weight circuit and completed three sets of each primary exercise before moving on to the next one. A single-factor between-subjects analysis of variance (ANOVA) was used to determine the effects of the exercise program and level of maturity on muscular strength in the subjects. Following nine weeks of progressive overload circuit training, the training groups showed significant increases in both upper and lower body strength. Strength increases were found to be significant for all three maturity levels.

Sewall and Micheli (1986) compared the responses of prepubescent children to strength training with an age-matched control group. The treatment group trained for nine weeks, three times per week, performing three sets of 12 repetitions. The control group was not allowed to participate in any strength training for the duration of the experiment. Initial strength measurements were taken for knee flexion/extension and shoulder flexion/extension. Grip strength was also measured pre- and post-treatment. After completion of the training, both groups were asked to engage in only their normal activities for another nine week period. This was a period of detraining. Strength measurements were taken prior to training, after nine weeks of training, and again after 9 weeks of detraining. Shoulder flexion was found to have the most significant strength gains. Grip strength also increased as a result of the strength training program. All three of the muscle groups that were specifically targeted by the training program showed significant increases in strength. An overall increase in strength of more than 40% was noted during the nine week training period. No injuries were reported to have occurred during this study. These results support the argument that pre-pubescent children will experience strength gains in response to a progressive overload resistance exercise program. The detaining period indicated that these strength gains can be reversed (decrease in strength), if followed by a period of no strength training (detraining).

Weltman et al. (1986) investigated the effects of hydraulic progressive overload circuit training in pre-pubertal males. Thirty-two boys between the ages of 6 and 11 years participated in the 14-week experimental period. The subjects were assigned to either a strength training group or a control group. The control group was not allowed to participate in any strength training during the experimental period of the study. Initial measures of isokinetic strength, average concentric work (Joules), and average torque (N-m) were measured pre-training and post-training. Each training circuit consisted of 30 seconds of constant exercise, with the participant attempting to complete as many repetitions as possible in the allotted time. The hydraulic equipment permitted concentric reciprocal movements including: biceps/triceps, quadriceps/hamstrings, and hip abduction/adduction. Additional exercises included hydraulic bench press, shoulder press, and butterfly, as well as jump squats, sit-ups, and stationary cycling. Three circuits were completed per training session. A 2 x 2 analysis of variance (ANOVA) with repeated measures was used to analyze the changes in strength in all motions over time. The strength training subjects doubled their isokinetic strength for the eight motions tested, with changes in the training group being significantly greater than those of the control group. The results demsonstrated significant strength gains as a result of a short term, circuited, hydraulic exercise resistance training program.

Rians et al. (1987) conducted a study to investigate the safety of strength training for the prepubescent male. Taking 32 healthy, untrained 8-year old males, the training group was trained three times per week for 14 weeks. The training group performed as many repetitions as possible within a 30 second working interval, allowing concentric work only. Load was increased only upon full completion of 30 repetitions within the 30 second working interval. The control group was not allowed to complete any type of strength training. Initial measurements of growth and development (anthropometrics), flexibility (sit and reach test), and motor performance (standing long jump and vertical jump tests) were taken. The purpose for data collection was to determine whether the training group had changes in strength, motor performance, and flexibility when compared to the control group. Safety was evaluated using injury surveillance by the participating physician (Rians) separating the injuries that occurred as a result of the strength training versus the injuries that occurred as a result of participation in sports and recreational activities. Injuries were defined as those reported complaints that kept a participant from completing an entire circuit or from attending a training session. Additional safety measures included blood pressure measurement, heart rate monitoring, musculoskeletal scintigraphy and creatine phosphokinase measurement. Rians et al.

found the training group to have significant strength gains in all four motions tested (elbow flexion/extension, knee flexion/extension). The training group had increased vertical jump heights, yielding improvements in the motor performance measure. No short term injuries to bone, bone growth tissue and/or muscle were found as a result of the study. Rians et al. concluded that with close supervision and a safe, properly designed exercise regimen, concentric strength training yields strength gains and does not increase the risk of injury.

Mersch and Stoboy (1989) investigated the effects of strength training on strength and muscular hypertrophy in children. The participants were two pairs of male twins, between ages 8 and 11 years old. One of the twins served as the control group, with the other twin served as the training group. The training group was placed in a fixed, reproducible position and asked to contract their quadriceps of the left leg with maximal effort, for 10 seconds, 10 times per day, six days a week for two months. The strength levels of the training group were measured once per week. Both groups (training and control) showed increases in strength due to body growth. However, the trained muscle group showed significantly greater increases in strength than the untrained muscle group. Mersch and Stoboy concluded that muscular hypertrophy and strength gains can occur utilizing an isometric strength training program in boys between the ages of 8 and 11 years old. Mersch and Stoboy suggest future research is needed including a larger sample size.

Ramsay et al. (1990) examined the effect of 20 weeks of a high intensity, progressive resistance training regimen on maximal voluntary strength, evoked contractile properties, muscle cross-sectional area, and motor unit activation in prepubescent boys. The research significance was to identify possible reasons for strength gains, along with a possible time line for adaptations. The participants were 26 healthy, untrained males between ages 9 and 11. The participants were split into an experimental (lifting) group and a control group. The experimental group trained three times per week for 20 weeks, implementing five sets of primary exercises (biceps curl and double leg extension), and three sets of secondary exercises (leg press, bench press, lat pull down, and sit-ups) in a circuit format. Participants in the control group were not permitted to weight train during the study, but were allowed to continue their normal daily activities. The one repetition-maximum (1RM) was measured for each participant on the leg press and the bench press. The maximal isokinetic concentric strength and evoked contractile properties of the right elbow flexors and knee extensors were used as initial measures. Computerized measures of muscle cross-sectional areas of the right mid-upper arm and the right mid-thigh were taken, as well as the percent of motor unit activation in the right elbow flexors and the right knee extensors. Percent body fat was also measured. The independent variables were the two training groups (weight training, non-weight training) and the dependent variables were performance strength, isometric strength, isokinetic strength, maximum voluntary torque, evoked contractile properties, computerized axial tomography, muscular endurance, and anthropometry. The dependent variables were measured pre-training (week 0), mid-training (week 10), and post-training (week 20). The 20-week progressive overload training program significantly improved performance strength for the 1RM bench press and leg press in the experimental group.

The program also yielded improvements in isokinetic peak torque values and maximal voluntary isometric peak torque (elbow flexion and knee extension). These results confirm that voluntary strength in prepubertal children can be increased as a result of a progressive overload strength training program.

Using a progressive overload design, Russell (1991) studied the effects of resistance training on upper body muscular strength and endurance in elementary school children. The training in the study consisted of a thrice weekly training regimen, 10 weeks in duration. Two types of training were utilized: upper-body weight training and modified pull-ups. One group performed bent-over rows in sets of 20 repetitions. Upon successful completion of 20 repetitions, they progressed in load lifted with weight increments being as follows: "…3, 5, 8, 10, 13, 15, 17, 19, 21, and 23 pounds" (pg. 29). The other group performed modified pull-ups until failure. Failure was operationally defined as "…the point at which the subject can not perform another repetitive exercise due to fatigue" (pg. 5). The results indicated greater strength gains in the weight training group than in the modified pull-ups training group. Therefore, Russell concluded that third, fourth, and fifth graders could significantly increase their upper body strength and endurance through a progressive overload resistance training program.

Fukunaga, Funato, and Ikegawa (1992) investigated the effects of resistance training on muscle area and strength of the upper arm in prepubescent boys and girls. The participants were 99 children in 1st, 3rd, and 5th grades. The participants were assigned to the training group or the control group. The training group participated in a 12-week training program. The training participants were asked to complete three maximally sustained isometric contractions of elbow flexion twice a day for ten seconds, three days per week. The control group did not participate in any strength training during the experimental process. Muscle area was measured by ultrasonic method and skeletal age was determined by hand-wrist x-ray. The training group showed significant increases in muscle area in all groups except for the first grade males. The muscle area for the fifth grade training groups increased significantly greater compared to the 3rd grade and 1st grade groups. Significant correlations were found to exist between cross-sectional areas of muscle and strength of elbow flexors and extensors. Fukunaga, Funato, and Ikegawa concluded that strength training can increase muscle cross-sectional area and isometric strength levels in 1st, 3rd, and 5th grade children.

Faigenbaum et al. (1993) evaluated the effects of a short-term, twice-a-week strength training program on children ages 8-12. Twenty-five boys and girls participated in the 8-week training program. Participants were randomly assigned to a training group or a control group. Each child's 10-repetition (10RM) maximum was determined, using child-sized dynamic resistance exercise equipment. The five exercises for which 10RM were determined were leg extension, leg curl, bench press, overhead press, and biceps curl. The training group trained twice per week on nonconsecutive days, with each workout lasting approximately 35 minutes. Training consisted of three sets of 10 repetitions, with loads of 50%, 75%, and 100% of 10-RM respectively performed for the first to last set. Subjects also progressed from one set of 10 repetitions to three sets of 15 repetitions on two ancillary exercises (abdominal curls and bent-knee leg raises). A two-way between-subject analysis of variance (ANOVA) with testing as the repeated measure was conducted to determine the effects of strength training on strength. Significant strength gains were found in both the upper and lower body. These results indictated that strength gains can be attained training twice per week in a progressive training program. The authors recommend a bi-weekly training program for untrained children when beginning their training.

Ozmun et al. (1993) investigated neuromuscular adaptations following eight weeks of isokinetic and isotonic strength training. Ozmun et al. used concentric muscle contractions instead of eccentric contractions in an effort to reduce potential muscle soreness and/or injury. The participants were 16 male and female children between the ages of 9 and 12 years old. The participants were randomly assigned to the training group (experimental group) or the control group. Isokinetic strength and isotonic strength were measured pre- and post-training, using elbow flexion of the right arm. Each subject performed three practice trials, followed by five maximal efforts with 1-minute rest periods separating each effort. Isotonic elbow strength was determined using a weighted dumbbell. Electromyography (EMG) data were also collected during each test trial, with electrodes placed longitudinally along the belly of the biceps brachii. The training group trained three times per week for 8 weeks, with at least one day of rest between training sessions. For the training group, training sessions began with two sets of seven repetitions, followed by three working sets of a load that could be lifted 7-10 times using correct form. When the subject could perform 11 repetitions correctly, the weight increased approximately 1.4 kg. A 2 x 2 analysis of variance (ANOVA) was conducted to determine if differences existed over time in isokinetic and isotonic strength measures between the training and control groups. Results revealed a 27.8% increase in isokinetic strength and a 22.6% in isotonic strength in the training group. In conjunction, the training group had a 16.8% increase in neural activity, as indicated by the recorded EMG activity. By using EMG monitoring, Ozmun et al. were able to investigate neuromuscular activity and associate strength gains with increases in motor unit activation as a result of strength training. The results of this study indicate that following an eight week strength training program, prepubescent children can increase levels of voluntary strength.

Faigenbaum, et al. (1996b) evaluated the effects of strength training and detraining on 24 healthy, untrained boys and girl, ages 7-12. Three boys and six girls matched for maturity and age served as the control group. The other testing group was the strength training group. The training program consisted of eight weeks of bi-weekly training sessions, progressive in design, including a six repetition maximum (6RM) pretest and posttest on the leg extension and chest press machine. Vertical jump tests were used to measure lower body motor performance. The detraining period was eight weeks and no strength training was performed. Analysis of variance (ANOVA) with testing as the repeated measure (pre- and post-tests of performance strength) was conducted to identify the significance of the effect of strength training on performance strength. The training group demonstrated significant strength gains during the 8 week training phase, with greater gains being recorded during the latter 4 weeks of training. During the 8 weeks of detraining, significant losses in both upper and lower body strength (19.3% and 28.1%, respectively) were recorded, with the greatest losses being recorded during the initial 4 weeks. By testing the effects of training and detraining, Faigenbaum et al. were able to show that strength gains are attainable and reversible.

Within the fields of pediatric medicine, public health, and exercise science all merging together to establish the most optimal settings for improvement of the health and fitness levels of present day youth, Sothern et al. (2000) examined the safety of, feasibility of, and level of compliance with a resistance training program in prepubescent, obese children. The treatment group consisted of 19 boys and girls, between the ages of 7 and 12 years, who participated in a 12 month, four phase weight management and exercise program. The exercise portion of the treatment was an instructional home-based exercise program, 30-45 minutes in duration, completed at a moderate intensity level. The intensity level was operationally defined as 45-55% of VO2 max and 55-65% of predicted maximal heart rate. All participants exercised within these moderate intensity ranges of VO2 and heart rate. The participants completed a balanced routine of six different exercises during the initial phase, designed specifically for obese youth. When the participant progressed into the next phase of the program, 2-3 exercises were added to their overall regimen until they reached 12 exercises total during the final phase. The participants complete one set of 8-12 repetitions at an intensity of approximately 60% of 1RM. Participants began the program by following the exercise instruction from the program video without additional weight or external resistance. After 4 weeks, the clinical exercise physiologist instructed the children on proper lifting technique, while parents served as spotters. Participants were instructed to continue to follow the video instruction 2 times per week with at least one day of rest in between. Parents were asked to use the spotting techniques at home to increase safety. In week 4, external resistance was provided by ankle weights and hand weights, weighing 2.5 pounds and 1 pound respectively. The upper/middle back exercises required use of resistance tubing. Participants initially performed eight repetitions per exercise, increasing to nine repetitions when eight were performed with correct form. This progressive pattern was continued until 12 repetitions were completed and then the load was increased to 5 pounds for each ankle and 3 pounds for each hand. When the load was increased, the repetitions were decreased back to eight. A two-way, repeated-measure, analysis of variance (ANOVA) revealed significant differences for measurements taken at three different time points over the 10-week testing period. Sothern et al. found that a consistent, safe, strength training routine performed for approximately one year led to a significant decrease in body mass index, decrease in body fat percentage, and a low risk of injury. No injuries due to the prescribed program were reported. They also concluded that resistance training could provide an attractive alternative type of exercise for those children normally exposed to traditional recreational types of physical activity or who might not be prone to join a team-based sport.

Faigenbaum, LaRosa Loud, O'Connell, Glover, O'Connell, & Westcott, (2001) investigated the effects of various resistance training protocols on upper body strength and endurance in children. Sixty-six children between ages 5 and 11 volunteered to participate in the study. They were split into five training groups, with overall training duration being split into two phases. During phase 1, approximately half of the participants were randomly assigned to a heavy-load, low-repetition training group (HL), moderate-load, high-repetition training group (ML), or a control group (CT). During phase 2, the other half of the participants (not previously assigned) were randomly assigned to a complex training group, (CX), which performed a combination of low-repetition, heavy-load training and medicine ball exercises, or to a medicine ball only training group (MB). Each subject's 1RM was determined on the vertical chest press before the start of the 8 week training program. Training sessions were twice per week, with the heavy-load, low-repetition group completing 6-8 repetitions on all exercises and the moderate-load, high-repetition group completing 13-15 repetitions. The participants in the CX group completed 13-15 repetitions on the ten selected exercises, except on the vertical chest press. They completed 6-8 repetitions on the vertical chest press and immediately followed with 6-8 chest passes with the medicine ball. In the MB group, the subjects performed 13-15 chest passes with the medicine ball instead of the vertical chest press exercise. The MB group started with a 1kg medicine ball and gradually progressed to a 2.5 kg medicine ball by the seventh week of training. A two-way analysis of variance (ANOVA) with the repeated measure of time was conducted to identify any changes in 1RM strength. Strength gains were significant in the ML and CX groups, with a greater training volume being responsible for greater gains in the upper body strength levels. Both the ML and CX groups also recorded greater gains compared to the HL, CT (control) and MB group. Faigenbaum et al. concluded that upper-body strength and muscular endurance in untrained children can be increased as a result of a high-repetition training design during the initial phase of strength training.

Flanagan et al. (2002) investigated the effects of strength training on children's ability to run, jump, and throw, as well as the effects of different strength training modes on actual performance outcome. The types of training included specialized (machine resistance) training, body weight training, and recreational training (normal physical education class). The specialized training group trained bi-weekly for 10 weeks with a progressive overload regimen. The body weight training group was also able to complete a progressive overload resistance type design by progressing to exercises requiring greater amounts of muscular coordination and control. Data were analyzed using a 2x2 analysis of variance (ANOVA). The independent variables were treatment group (machine-resistance, body weight-trained, control group) and strength testing (pre-training and post-training). The dependent variables were the sitting medicine ball put, standing long jump, and the agility run. The specialized training and body weight training yielded strength gains significantly greater than the control group with the specialized group reporting the largest strength gains. Flanagan et al. concluded that machine resistance training produced larger strength gains than body weight training in children. Both modes of progressive overload strength training, specialized (machine) and body weight training, produced significant strength gains in the participants.

Faigenbaum, Milliken, and Westcott (2003) investigated the effects and safety of maximal strength testing in healthy children. The study consisted of 1RM testing in healthy children between the ages of 6 and 12. Thirty-two girls and 64 boys volunteered to participate in the study. The children each performed a 1RM test on either the standing chest press or the seated chest press, and a 1RM test on either the leg press or leg extension machine. All tests were performed under close supervision with a coach to participant ratio of 1:1. No injuries resulted and the testing protocol was found to be healthily tolerated by the participants. The findings supported and demonstrated that healthy children can safely perform 1RM testing under appropriate procedures and supervision.

The investigations of children and adolescent responses to resistance training programs demonstrate that children between the ages of 7 and 18 years can experience strength gains as a result of participation in a resistance training program. The studies indicate that strength gains are possible upon completion of a resistance training program, as well as reversible if training is not continued consistently (Sewall & Micheli, 1986; Faigenbaum et al., 1996b). Thus, the research supports the use of resistance training in youth as a method of increasing muscular strength.

Prepubescent and Adolescent Resistance Training Volume Investigations

Insufficient research has been done investigating the impact of training volume on the effectiveness of resistance training in prepubescent and adolescents. Volume is defined as the total number of repetitions completed during one workout session (Pauletto, 1985). The variable of volume is essential in program design as it directly dictates the total number of sets and repetitions that are to be completed during a single training session. To understand the effects of training volume on the participant prescribing an appropriate training frequency (days per week) and training intensity (percentage of one-repetition maximum) is necessary.

Faigenbaum et al. (1999) compared the responses of a low-repetition, heavy-load training program to a high-repetition, moderate-load training program in children. Thirty-three boys and eleven girls between the ages of 5 and 12 years old participated. The participants were randomly assigned to a low repetition-heavy load group, high repetition-moderate load group, or a control group. Each participant's one repetition maximum (1RM) was tested pre-training on the vertical chest press and leg extension. One repetition maximum measures were tested again after four weeks of training, and after eight weeks of training. Training sessions consisted of 10 minutes of low intensity aerobic exercise and stretching, followed by approximately 30-40 minutes of resistance training. The resistance training consisted of one set of 11 exercises. The exercises selected were abdominal curls, lower back extensions, leg extension, leg press, leg curl, hip abduction, pullover, vertical chest press, seated row, abdominal flexion, and front pull down. The low repetition-heavy load group performed 6-8 repetitions and the high repetition-moderate load group performed 13-15 repetitions. When subjects could perform eight complete repetitions (in the low repetition group) or 15 complete repetitions (in the high repetition group), their load was increased 5-10% and repetitions were decreased back down to their respective minimums. An analysis of variance (ANOVA) with repeated measures was conducted to determine any differences between groups for tests of muscular endurance and strength. The high-repetition, moderate-load training group demonstrated significant strength gains, with greater gains during the last 4 weeks of training. The high repetition group showed significantly greater strength gains compared to the low repetition group overall. The high repetition group was the only group to make significant gains in 1RM strength and muscular endurance in the vertical chest press exercise. Faigenbaum et al. concluded that muscular strength and muscular endurance can be improved during childhood utilizing a high repetition-moderate load resistance training program during the initial training period. An alternative explanation of the results of this study could include that strength gains could have been attributed to the greater training volume of the high-repetition-moderate load group, indicating that volume affected the amount of strength gains as well.

Faigenbaum et al. (2002) compared a once per week and twice per week progressive strength training program on total body strength and motor performance ability in children. The participants volunteered to participate in either the once per week or twice per week group, with an additional 13 children serving as a control group. Each training session consisted of one set of 10-15 repetitions on 12 selected exercises using child-sized strength training equipment. Each subject's 1RM was determined on the seated chest press and leg press prior to training and immediately following the 8-week training period. During the training period, if a subject could complete all 15 repetitions at the selected load, the load was increased 5-10%, with repetitions decreased back to 10. The order of exercises during each training session was changed in order to prevent boredom and maintain variety for the subjects. A two-way analysis of variance (ANOVA) was conducted to test for differences between subject groups and to test for differences in pre-training and post-training measures. Comparing 56 healthy, untrained boys and girls, between the ages of 7 and 12, Faigenbaum et al. found that the bi-weekly training group made significant strength improvements in both their upper and lower body strength. The group that trained once per week gained approximately 78% and 57% in upper body and lower body strength when compared to the bi-weekly training group. They concluded that a higher training volume proved more beneficial for increased motor unit activation, strength gains, and overall improved physical condition. Faigenbaum et al. suggest that in future research studies training volume be similar between training groups.

Insufficient research has been done on the effects of training volume on the responses of children and adolescents to resistance training. Of the research conducted, it has been concluded that higher volume training programs result in greater strength gains and overall improved physical condition as opposed to lower training volumes. Further research is recommended to determine the exact nature of the relationship between training volume, training frequency, and specific muscular strength gains.

Prepubescent and Pubescent Female Resistance Training Investigations

Much of the research conducted on the responses of prepubescent and adolescent resistance training has included males only or a combined subject pool males and females. There has also been very little research done strictly on young females, especially below age 11 (Payne, Morrow., Johnson, and Dalton, 1997). In addition, insufficient research has been done to compare the relative effectiveness of a resistance training program on preadolescent and adolescent boys versus preadolescent and adolescent girls.

Siegel et al. (1989) investigated the effects of upper body resistance training on muscular strength and endurance and body composition in prepubescent children. Siegel et al. utilized a circuit type training format, but included unconventional types of training as well. The participants were third grade students (boys and girls) from two different schools. Each participant completed a pre-training muscular strength test (chin-ups/flexed arm hang), pre-training muscular endurance test (amount of sit-ups completed in 60 seconds), pre-training right and left handgrip strength, and a pre-training sit and reach test. The children were selected to be part of the control group or the experimental group. The children in the control group engaged in 30 minutes of free play, including snacks, socializing, kickball, jump rope, etc. The experimental group participated in one of three various types of training. One group completed an obstacle course with body weight, upper body, locomotor movements (wheelbarrow, crabwalk), another performed a choreographed weight routine using tennis ball cans or detergent bottles filled with sand, and a third group carried out a circuit weight training regimen using various accessories (e.g., tennis balls for squeezing, strips of rubber tires to pull). The independent variables were strength training with four levels (body weight upper body, choreographed, circuit weight training group, and control), and sex (male, female). The dependent variables were the effects of the training program (strength, endurance and flexibility measurements). Analysis of variance (ANOVA) was used to evaluate the differences between training groups as well as between sexes of subjects. The results demonstrated that boys were significantly stronger than girls on each of the strength measurements, with the differences being the greatest on the chin-up/flexed arm hang. An analysis of covariance (ANCOVA) was conducted to investigate the differences between training groups and sexes with respect to changes over time. The independent variables were training group, sex, and the interaction between training group and sex. The dependent variables were the pre-training and post-training scores (muscular strength, muscular endurance, and flexibility). The results demonstrated that the training groups showed higher strength levels in the right handgrip, chin-ups, and flexed arm hang, compared to the control group. The training groups also demonstrated higher scores on the sit-up test than the control group. There were no significant differences between boys and girls with respect to changes over time. Siegel et al. concluded that a school based program of group strength training can be an successful method for increasing right handgrip, flexibility, and upper body muscular endurance in prepubescent boys and girls.

In 1980, Nielsen, Nielsen, Behrendt Hansen, & Asmussen, 1980. tested isometric strength in knee extension and functional muscular strength. Assessment of the height of the vertical jump and the acceleration in a sprint were used to determine effects of functional strength in the participants. Female participants between the ages of 7 and 19 were trained three times per week for 5 weeks. The specific training program lasted approximately 12 minutes, following a 6-8 minute general warm-up. An analysis of variance (ANOVA) was conducted to analyze the functional strength changes over time. The results yielded the greatest training effects reflected the most in the tests that the participants had been specifically trained for. With the exception of sprint training, the findings demonstrated that strength gains from resistance training can possibly be transferred to vertical jumping. It was determined that training specificity might be necessary when strength training is designed to improved specific movements.

With previous research focusing on prepubescent and adolescent males or males and females combined and/or only prepubescent and adolescent males, the effectiveness of strength training programs for a young female population has yet to be investigated in depth. Therefore, it is suggested that future research investigate the responses of both preadolescent and adolescent males and females, comparing the results of the two populations. It is also suggested that due to the lack of research isolating preadolescent and adolescent females, future research should focus on female responses only.

Summary

Research studies that have investigated the responses of resistance training in prepubescent and adolescent children have demonstrated that strength gains are possible upon completion of a resistance training program (Faigenbaum et al., 1993; Faigenbaum et al., 1996b; Faigenbaum, Milliken, & Westcott, 2003; Flanagan et al., 2002; Fukunaga, Funato, & Ikegawa, 1992; Gallagher & DeLorme, 1949; McGovern, 1983; Mersch & Stoboy, 1989; Ozmun et al., 1993; Pfeiffer & Francis, 1986; Ramsay et al., 1990; Rians et al., 1987; Russell, 1991; Servedio, 1984; Sewall & Micheli, 1986; Sothern et al., 2000; Weltman et al., 1986). Insufficient research has been completed investigating the effects of training volume on the responses of children and adolescents to resistance training (Faigenbaum et al., 1999, Faigenbaum et al., 2002). There have also been very few studies investigating the differences between the responses of pre-adolescent and adolescent males and females to resistance training (Siegel et al., 1989), as well as the responses of young females to resistance training (Nielsen, Nielsen, Behrendt Hansen, & Asmussen, 1980). Of the articles reviewed for the present study, 16 studies used male and females in the participant pool (Faigenbaum et al., 2001; Faigenbaum, Milliken, & Westcott, 2003; Faigenbaum et al., 2002; Faigenbaum, Westcott, LaRosa Loud, & Long, 1999; Faigenbaum et al., 1996b; Faigenbaum, Zaichkowsky, Westcott, Micheli, & Fehlandt, 1993; Flanagan et al., 2001; Fukunaga, Funato, & Ikegawa, 1992; Gallagher & DeLorme, 1949; McGovern, 1983; Russell, 1991; Sewall & Micheli, 1986; Sothern et al., (2000); Ozmun, Mikesky, & Surburg, 1994; Siegel, Camaione, & Manfredi, 1989), 8 used only male subjects (Falk & Tenenbaum, 1996; Mero, Kauhanen, Peltola, & Vuorimaa, 1988; Mersch & Stoboy, 1989; Pfeiffer & Francis, 1986; Ramsay et al., 1990; Rians et al., 1987; Servedio, 1984; Weltman et al., 1986), and only one study tested female subjects (Nielsen, Nielsen, Behrendt Hansen, & Asmussen, 1980). Therefore, the implication is more research is needed related to issues surrounding strength training in pre-adolescent and adolescent females.

Chapter 3

Research Design and Methodology

The following section is a detailed description of the methods that were employed to investigate the effects of frequency of strength training on strength gains achieved in prepubescent girls.

Participants

For this study, 31 prepubescent girls volunteered from the metropolitan area in and around San Jose, California, to complete a strength training program. Of the thirty one participants that began the study, five were asked to withdraw due to their absence during the first two weeks of training sessions. To obtain a prepubescent participant pool, potential participants and their parents completed a questionnaire (see Appendix A) regarding age of menarche (Beunen, deBeul, Ostyn, Renson, Simons, & vanGerven, 1978). Based on their questionnaire answers, the prepubescent participants were asked to participate in the study. If a participant and/or their parent/legal guardian declined to answer any part of the questionnaire, they were not asked to participate in the study. This was to ensure that all of the participants were prepubescent. There were no participants that declined to answer the questionnaire in this study. These participants were randomly assigned to either the twice per week training group (TG2) or the once per week training group (TG1). There were an equal number of participants in both TG1 and TG2. Participants received a signed clearance through their primary care physician prior to the study stating that an evaluation of the musculoskeletal system was completed to rule out any medical contraindications to strength training, and to document severe previous injuries specifically related to their ability to do strength training. Participants with any severe previous injuries that would affect their ability to complete any of the selected lifts included in the strength training program, were not allowed to participate in the study. Participants had to have no history of partaking in any structured strength training within the 2 months preceding the study (Baechle & Earle, 2000).

Obtaining Consent

Participants returned a signed consent form (see Appendix B) from their parents or legal guardians stating that the child had permission to participate. The parents or legal guardians also signed an agreement that their child would be able to consistently attend the 10 weeks of bi-weekly or once-weekly training sessions. The child also returned a signed consent form (see Appendix C) in which they agreed to consistently attend the 10 weeks of bi-weekly or once-weekly training sessions and put forth their best effort possible for the duration of each training session.

Equipment

The seven exercises that were included in the strength training program were the back squat, dead lift, supine bench press, standing calf raise, seated row, seated dumbbell curls, and standing military press and were selected based on a beginning strength training total body program design (Baechle & Earle, 2000; Kraemer & Fleck, 1993). Testing and strength training procedures were completed using Eleiko-Sweden brand barbells and rubber plates, York brand barbells, Bigger, Faster, Stronger (BFS) Aluma Lite barbells, and Hampton dumbbells. In the back squat exercise, 4.85 cm. PVC pipes, Eleiko-Sweden 5-kilogram barbells, BFS Aluma Lite 7 ½ – kilogram training bars, and both Eleiko and Mav-Rik brand rubber plates weighing between 1 kilogram and 15 kilograms were utilized. For the dead lift exercise and supine bench press, the same equipment was used. For the seated calf raise, Heavy Metal brand short barbells were used in loads ranging from 9.1 kg to 50kg. For the seated dumbbell curls, and standing military press, Hamilton dumbbells ranging from 1.4 kilograms to 22.7 kilograms were used. For the seated row exercise the Body Masters cable cross jungle gym hi/low pulley system, model number MD2094-6 was used.

Testing Procedures

Based on Faigenbaum, Milliken, and Westcott's (2003) method of measuring 1 repetition maximum (1RM), each participant's 1RM was determined for the back squat, dead lift, supine bench press, seated calf raise, seated row, seated dumbbell curls, and standing military press. Each participant's 1RM was determined pre and post training with a representative 1RM measurement taken at the conclusion of the 4th week and 7th week to measure incremental strength changes. In the 4th and 7th week one representative 1RM was measured for the upper body (supine bench press 1RM) and the lower body (back squat 1RM). These two specific lifts were chosen because they activate the greatest number of muscles in the upper body and lower body respectively. Each participant's 1RM was recorded as the maximum amount of weight that could be lifted correctly throughout the full range of motion one time. Before attempting a 1RM, participants performed six repetitions with a relatively light load, then three repetitions with a heavier load, and finally a series of single repetitions with progressively increasing loads. If the participant was able to lift the load with proper form, the load on the next lift was increased by approximately 0.5-2.3 kg, and the participant attempted another single repetition. The increase in load depended on the amount of effort required for the lift just completed and became progressively smaller as the participant neared their 1RM. Failure was defined as a lift falling short of the full range of motion on at least two attempts separated by at least two minutes of rest (Faigenbaum et al., 2003). Each participant was taken through an introductory session (Faigenbaum et al., 2003), prior to testing in order to learn correct lifting techniques, appropriate lifting cues and breathing procedures to reduce the influence of the learning effect, and to become familiar with basic strength training guidelines (Faigenbaum, LaRosa Loud et al., 2001). This made the testing time more efficient since the participants were already familiar with the required movement patterns and lifts. Each participant completed a ten-minute warm-up session (Faigenbaum et al., 2002) of low-to-moderate intensity aerobic exercise (ladder drills, jogging, and jump rope) and stretching. All measurements for testing were supervised by the same test administrators. After 1RM procedures were concluded, subjects completed a 10 minute cool down and stretching period.

All testing procedures were administered by a National Strength and Conditioning Association Certified Strength and Conditioning Specialist. The test administrator to participant ratio was 1:1. Each test administrator (Certified Strength and Conditioning Specialist) had previous experience working with boys and girls in a strength training environment and understood the psychological and physiological differences between children and adults. Communication between the test administrator and participants was continuous and positive.

All testing procedures took place at Focused Individualized Training (FIT), located in Los Altos, CA. A maximum number of six participants were allowed to participate in 1RM testing procedures at one time to maintain the test administrator to participant ratio at 1:1. Each 1RM testing session took approximately 2 hours to complete. Approximately 2-4 days after the initial strength tests, subjects returned to the testing facility and were individually questioned by the researcher regarding the presence of injury and/or muscle soreness. If muscle soreness caused the participant to alter or cease any types of physical activity, then it was considered too severe and the participant ceased further participation in the study (Faigenbum et al., 2003).

Strength Training Program Administration

During the 10 weeks following the pre-training 1RM testing procedures, participants in the twice per week group each completed one training session per day on 2 nonconsecutive days each week. The one time per week training group completed on strength training session on 1 day each week. A training session for the once per week group consisted of a warm-up, two sets of each exercise at the participant's designated load, and a cool-down. A training session for the twice per week group consisted of a warm-up, one set of each exercise at the participant's designated load, and a cool-down. The difference between the training groups was the once per week group completed one set per session on 2 different days versus both sets on 1 day per week. The twice per week group had an entire week to recover before their next workout session. Training sessions were mixed with both twice per week and once per week participants working out together.

Spring break occured during the middle of the strength training period (weeks 3-5), which meant that some participants were out of town, on vacations and/or missed their regularly scheduled workout days. If a participant missed their normal workout sessions, they were required to come in on the day and time that was closest to their regular scheduled workout time. For example, missing a Monday, 3:30 p.m. workout meant that they were coming in on Tuesday at 3:30 p.m. This rule was enforced so as to maintain a workout schedule as close to their regular schedule as possible with consistent rest periods between workouts. If a participant was unable to make-up their session with fewer than 7 days between workouts, they were asked to withdraw from the study. This occurred during the first two weeks of the study but was not an issue during the remainder of the training period.

Consistent instruction was provided to reinforce proper techniques, breathing procedures, and potential benefits of each exercise. The coach (Certified Strength and Conditioning Specialist) to participant ratio during training was 1:3. Because of the large age range of the participants in this study, the ratio was seven athletes fewer than that recommended by the National Strength and Conditioning Association (Baechle & Earle, 2000) for junior high facilities. Both the once per week and twice per week strength training session each consisted of a 10 minute warm-up, approximate 40-60 minute working period (American Academy of Pediatrics, 2001), and a 10 minute cool-down and stretching period. The training program consisted of one set of 12-15 repetitions of the seven basic exercises, with exercise order changing every session due to the number of participants training at one time. The number of repetitions was selected based on

Faigenbaum et al. (1999) and the conclusion that a high repetition, moderate load progression is more appropriate for a beginning, prepubescent child than a low repetition, high load progressive design. When the participant were able to complete 15 repetitions through their entire set of a single exercise, the weight was increased 2.5-5% of the overall load and the repetitions were reduced back to 12 in that specific exercise (Earle & Baechle, 2004).

Participants trained in groups of two per station. Each participant received their personal workout log at the start of each session. The loads were filled in by the researcher prior to each session so that the participant had to check off the load that was completed that day. The target number of repetitions was written in parentheses next to each line on their workout log, and the participant wrote in the number of repetitions completed on the blank line after finishing each lift. Each participant was responsible for recording their completed repetitions for each lift on their personal workout log while waiting their turn for their next lift. Participants were taught how to record data on the workout log (Appendix F; Appendix G), load weight on the bars, and did so for the duration of the 10-week training period. The researcher was responsible for reviewing the workout sheets daily to ensure data were recorded correctly, training volume (loads and sets) was updated correctly, and to make any necessary adjustments to a participant's individual training program. In addition to ensuring that the children were recording accurate accounts of their activities, one child per session was randomly selected and video-taped during their training session. At the end of each training day the researcher reviewed the tape to ensure that proper recording of each set of repetitions and load was performed on every lift. Any errors identified on the tape were addressed and corrected during the next training session. In addition, the videotape provided technique feedback and allowed the coach to make any suggestions and/or adjustments during the next training period. A change was made regarding the video taping of one participant per training session. After 4 weeks of training, none of the video footage was appropriate for usage in evaluation of the methods due to too much interference in the camera's field of view. The camera was placed in a fixed location. People who were working out at the testing facility, but not participating in the study, would often obstruct the view of the participant selected for observation. Thus, the participants being videotaped could not able to be clearly viewed. There was also a lack of staffing available to follow a single participant around so as to avoid this interference. Therefore, there was no applicable footage to use after the fourth week of the strength training program.

No additional strength training was allowed outside of the training study during the 10-week training period and while the post-training 1RM testing procedures were conducted.

Strength Training Exercises

In the back squat exercise, participants would stand on an Olympic-style lifting platform, starting with their feet hip width apart. They began with two warm-up sets of 15 body weight squats, to remind them of the correct movement pattern for the squat. The participant was then instructed to take a deep breath in, sit down as low as they could, keep their feet flat on the ground, chest up, head forward, and then exhale as needed while they stood back up. The participant was then instructed to step underneath the barbell and stand up, keeping their head forward, and let the bar rest on their upper back. The participant was then instructed to lift their elbows up behind them towards their spotter in order to create a "shelf" with their upper back for the bar to rest on. They were instructed to take a deep breath in, hold the chest up and out, keep their eyes forward, and take one or two steps backward, out of the rack to establish proper squatting position. All repetitions began from this position. The lifter was then instructed to keep their chest up, eyes forward, heels flat, and to slowly allow the hips and knees to bend (flex) while keeping the trunk tall and tight. They were instructed to squat as low as they could while maintaining a relatively constant trunk-to-floor angle. At the end of the downward movement phase, the lifter was instructed to drive their weight through the heels, keep the shoulders and chest up tall, eyes forward or slightly up, and extend the hips and knees at the same rate until standing back up in the starting position. Upon completion of the set, the lifter stepped forward (one or two steps) into the squat rack until the bar hits the supports and then slowly squat down until the bar was resting completely on the supports. For added safety, for those participants who did not have enough quadriceps strength to perform the back squat safely with the load on their upper back, a Dynamax medicine ball was placed beneath their glutes as a tactile cue for them to extend the hips and knees. This provided physical safety by reducing the likelihood of a child falling onto the floor with a loaded bar. This same method was also used for those participants who didn't fully understand the appropriate movement pattern necessary to complete the back squat safely. This gave the participant aid in adapting to the movement pattern of the exercise. As expressed by the participants, this provided some participants with psychological comfort. A few participants asked for the placement of the ball beneath them on workout days that their load was increased because they were afraid of falling due to the heavier weight. The ball was placed beneath them on the floor for the first one or two repetitions and then removed once they could execute the movement correctly. All participants were spotted one on one for the duration of each session.

In the dead lift exercise, participants again were instructed to start with the bar over the balls of the feet against the front of the lower leg, shoulders directly over the bar. The feet began hip-width apart, with the toes pointed slightly outward. The participant squatted, grasped the bar with a pronated grip, (or alternating grip when the load increased), and hands slightly wider than shoulder-width apart. Keeping the head forward, the participant was instructed to inhale, flatten their back, and keep their chest up, hips down, and heels in full contact with the floor. They were instructed to use their legs and hips to pull the barbell up off of the ground, maintaining a flat-back position, keeping the elbows fully extended, eyes forward, and chest up. Upon standing straight up, the arms were to remain fully extended, the shoulders depressed, and eyes forward. Once the participant was standing completely erect, the barbell was returned to the starting position (Baechle & Earle, 2000).

In the supine bench press exercise, participants were instructed to lay with their back flat against the bench, keeping feet flat on the floor. Both hands were in a closed, pronated grip position holding the bar even with the nipple level of the chest. Participants were instructed to take a deep breath in and lower the bar to the chest. The wrists remained in a neutral position and directly above the elbows. In the upward movement phase, the lifter was instructed to exhale and push the bar upward until the elbows were fully extended. The lifter was to keep a grip on the bar until it was racked (with the help of a spotter) (Baechle & Earle, 2000).

In the calf raise exercise, participants were instructed to sit on a bench with the feet approximately hip-width apart, body erect, and eyes forward. Their feet were placed halfway on a step 6 inches tall in order to establish 90 degrees of hip flexion. For those participants that were taller, leading to a greater degree of hip flexion, they sat on a 1-inch thick foam pad in order to establish a more accurate body position. Holding a Heavy Metal brand barbell across their lap just above the femoral epicondyles, cushioned by two towels, the participant was instructed to plantar flex their feet as much as possible, keeping their trunk tall and tight, chest up, eyes forward, and arms relaxed in their lap, balancing the barbell. When they returned back to the starting position, (letting the heels drop below the level of the step if flexibility permitted), it was in a controlled manner (Baechle & Earle, 2000).

During the seventh week of the strength training program, the calf raise exercise was removed from both groups' training programs. As the load increased, the limiting factor was not the actual weight of the lift, but the fact that supporting the load caused discomfort on the legs of the participants. This exercise was removed because the validity of the 1RM value obtained from the calf raise exercise as a representative measure of lower leg strength of each participant was suspect.

In the seated row exercise, participants were instructed to sit erect, feet hip width apart, knees slightly bent, with hands firmly gripping the handle in a closed, pronated position. Participants were instructed to take a deep breath in, exhale as they pull the weight towards their body, flexing the elbows, maintaining retraction and depression in the scapulae. They maintained a tall, tight trunk, chest up, shoulders back and were not allowed to jerk their trunk for added assistance. They were instructed to keep the elbows close to the body, next to the ribs, as they slowly returned the weights back to their starting position (Baechle & Earle, 2000).

For the seated dumbbell curls, the lifter was instructed to grasp two dumbbells with a closed, supinated grip. The dumbbells were shoulder-width apart with the inside of either dumbbell touching the lateral aspect of the quadriceps. The lifter was instructed to keep eyes forward, chest up and out, and shoulders back (scapulae retracted and depressed). The lifter bent (flexed) the elbows until the dumbbell was within approximately 4 to 6 inches of the anterior deltoids, keeping the trunk tall and tight. In the downward movement phase, the lifter allowed the elbows to slowly extend back to the beginning position keeping the trunk and head in the same position (Baechle & Earle, 2000).

In the standing military press (shoulder press) exercise, the lifter stood erect grasping the dumbbells with a closed, pronated grip. The grip was slightly wider than shoulder-width apart. The lifter was instructed to keep eyes forward, chest up, trunk tall and tight, and press the dumbbells overhead until their elbows were fully extended. During the downward movement phase, the lifter was allowed to slowly flex the elbows as they lowered the dumbbells toward their starting positions (just above the shoulders). In the subsequent upward movement phase, the lifter inhaled, kept eyes forward, chest up, trunk tall and tight, kept wrists rigid and in a neutral position, and pushed the dumbbells upward again until the elbows were fully extended. After the set was complete, the lifter kept a grip on the dumbbells until they were racked with help from the spotter (Baechle & Earle, 2000).

Data Analysis

The data analyzed were pre-training and post-training 1RM strength levels. Pre- and post-training mean 1RM strength levels were calculated for each group. The amount of strength change was statistically evaluated by comparing pre-training 1RM and post-training 1RM values by performing a two-way (group x time) mixed analysis of variance (ANOVA) with repeated measures on the time variable. The data was analyzed to test for differences between the once per week group and the twice per week group. In the back squat and supine chest press exercises, data were analyzed pre-training, at the end of week 4, at the end of week 7, and post-training.

Chapter 4

Results

The following section provides a detailed description of the results of this study. All participants completed the training program according to the aforementioned methodology and no injuries occurred during the study period or as a result of the training program.

Descriptive Statistics

To begin analyzing the differences in strength changes between the two training groups over time, the means (see Table 1) and standard deviations (see Table 2) of 1RM values were calculated. In the back squat, both groups reported their highest 1RM values (group 1, M=34.81 kg; group 2, M=39.88 kg) at the conclusion of the training period (post-test). In the supine chest press, both groups reported their highest 1RM values (group 1, M=18.54 kg; group 2, M=21.90 kg) at the conclusion of the training period (post-test). In the dead lift (group 1, M=40.65 kg; group 2, M=44.81 kg), the seated row (group 1, M=20.41 kg; group 2, M=23.31 kg), the seated dumbbell curl (group 1, M=6.38 kg; group 2, M=7.17 kg), and the standing military press (group 1, M=6.38 kg; group 2, M=7.41 kg) both groups reported their highest 1RM values at the conclusion of the training period (post-test) as well. Further analysis is provided to determine the significance of these values.

Table 1. Mean values of 1RM Values Pre-Training, Week 4, Week 7, and Post-Training within training groups (once per week or twice per week), N=13 in once per week group, N=13 in twice per week group

		Time of Testing			
Exercise	Training Group	Pre-Training	4 weeks	7 weeks	Post-Training
Back Squat	Once per Week	17.98	24.65	31.77	34.81
	Twice per Week	21.38	27.81	36.85	39.88
Supine Chest Press	Once per Week	12.81	17.35	17.77	18.54
	Twice per Week	15.96	18.50	19.85	21.90
Dead Lift	Once per Week	30.58	*n/a	*n/a	40.65
	Twice per Week	32.50	*n/a	*n/a	44.81
Seated Row	Once per Week	17.86	*n/a	*n/a	20.41
	Twice per Week	19.35	*n/a	*n/a	23.31
Seated Dumbbell Curl	Once per Week	4.43	*n/a	*n/a	6.38
	Twice per Week	4.76	*n/a	*n/a	7.17
Standing Military Press	Once per Week	4.32	*n/a	*n/a	6.84
	Twice per Week	5.63	*n/a	*n/a	7.41

Note. *n/a = not applicable because selected exercise 1RM was not tested at this time

Table 2. Standard deviation (SD) values of 1RM Values Pre-Training, Week 4, Week 7, and Post-Training within training groups (once per week or twice per week), N=13 in once per week group, N=13 in twice per week group

		Time of Testing			
Exercise	Training Group	Pre-Training	4 weeks	7 weeks	Post-Training
Back Squat	Once per Week	8.57	8.21	10.85	11.51
	Twice per Week	9.84	9.49	11.46	11.26
Supine Chest Press	Once per Week	4.45	4.95	4.90	5.55
	Twice per Week	4.42	5.10	4.52	4.88
Dead Lift	Once per Week	7.65	*n/a	*n/a	11.23
	Twice per Week	10.26	*n/a	*n/a	12.56
Seated Row	Once per Week	6.77	*n/a	*n/a	6.65
	Twice per Week	5.71	*n/a	*n/a	5.08
Seated Dumbbell Curl	Once per Week	.89	*n/a	*n/a	1.96
	Twice per Week	1.11	*n/a	*n/a	1.74
Standing Military Press	Once per Week	1.55	*n/a	*n/a	2.09
	Twice per Week	1.42	*n/a	*n/a	2.10

Note. *n/a = not applicable because selected exercise 1RM was not tested at this time

Statistical Analysis

To examine the effects of the groups and training program over time, six 2-factor mixed analyses of variance (ANOVA) were conducted. For the back squat and supine chest press, the two levels of the independent variable group (x1 per week or x2 per week) were compared over four levels of time for each lift (pre-training, week 4, week 7, and post-training). For the dead lift, seated row, seated dumbbell curls, and standing military press, the two levels of the independent variable group (x1 per week or x2 per week) were compared over two levels of time for each lift (pre-training or post-training).

Back Squat

There was no significant main effect found for the group, $F(1,24) = 1.35$. There was no significant interaction between time and group, $F(3,72) = .26$. There was a significant main effect for time, $F(3,72) = 61.20$, $p<.05$, indicating that further analyses were needed to determine the source of the effect.

To more specifically test the null hypotheses that stated there would be no statistically significant differences in the 1RM values from the beginning of the study to week 4, from week 4 to week 7, and from week 7 to the conclusion of the study, pairwise statistical comparisons were conducted. These comparisons indicated that there was a significant difference in the 1RM values from the start of the training to week 4, between week 4 and week 7 and from week 7 to the conclusion of the training (see Figure 1).

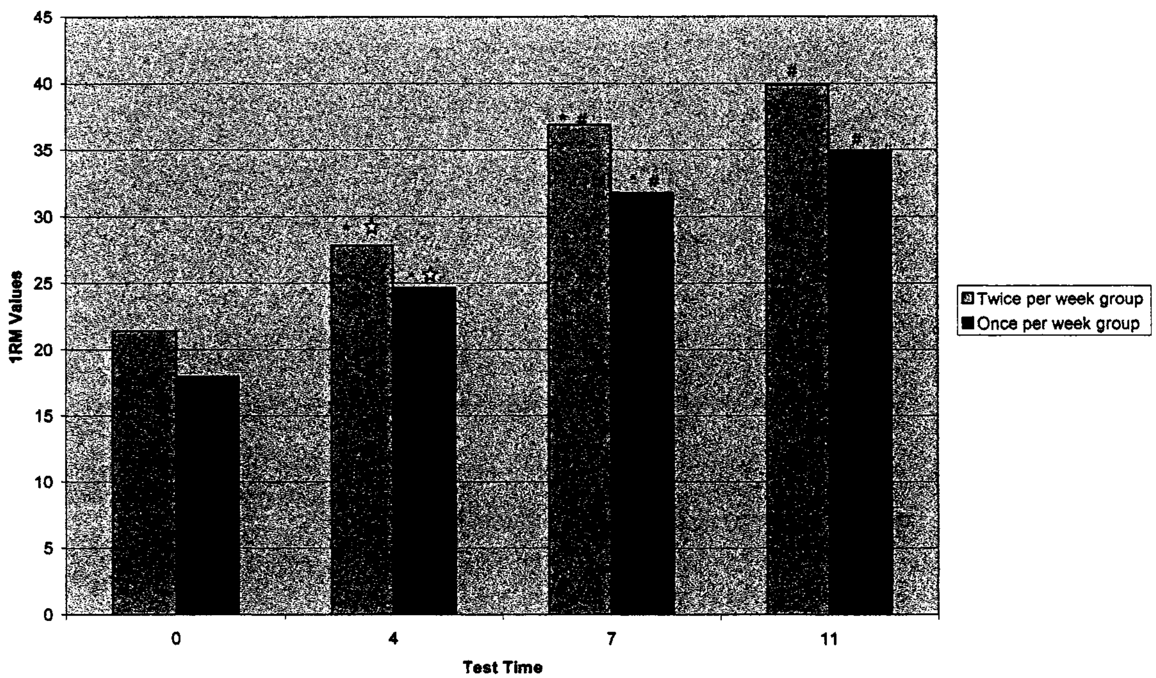

Figure 1. Back squat mean 1RM values by test time and group

Note. ☆ =statistically significant difference compared to pre-test; *=statistically significant difference between week 4 test and week 7 test; #=statistically significant difference between week 7 test and post-training test

During the first 4 weeks of training, the mean 1RM values increased 33.29%. From week 4 to week 7 of training, the mean 1RM values increased 30.79%. From week 7 to the conclusion of training, the mean 1RM values increased 8.86%.

<u>Supine Chest Press</u>

There was no significant main effect for group, $F(1,24) = 2.04$. There was no significant interaction between group and time, $F(3,72) = 1.08$. There was a significant main effect for time, $F(3,72) = 25.40$, $p<.05$ indicating that further analyses were needed to determine the source of the effect.

To specifically test the null hypotheses that stated there would be no statistically significant difference in the 1RM values from the beginning of the study to week 4, from week 4 to week 7, and from week 7 to the conclusion of the study, pairwise statistical comparisons were conducted. These comparisons indicated that there was a significant difference in the 1RM values from the start of the training to week 4, from the start of training to week 7, from the start of the training to the conclusion of training, and from week 7 to the conclusion of the training. There was not a significant difference in the 1RM values from week 4 to week 7 (see Figure 2).

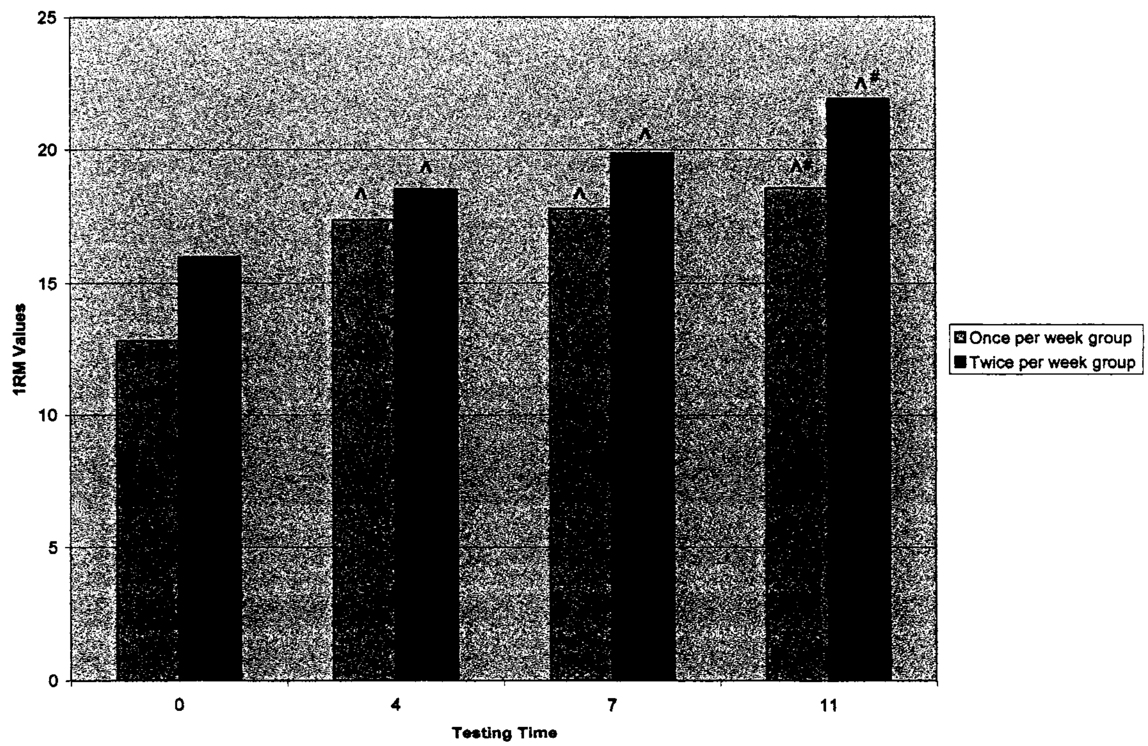

Figure 2. Supine chest press mean 1RM values by testing time and group
Note. ^ =statistically significant difference compared to pre-test; #=statistically significant difference between compared to week 7

From the start of training to week 4, the mean 1RM values increased 24.57%. From the start of training to week 7, the mean 1RM values increased 30.72%. From the start of training to the conclusion of training, the mean 1RM values increased 40.53%. From week 7 to the conclusion of training, the mean 1RM values increased 7.51%.

Dead Lift

There was no significant main effect for group, $F(1,24) = .64$. There was no significant interaction between group and time, $F(1,24) = .44$. There was a significant main effect for time, $F(1,24) = 44.37$, $p<.05$. There was a 35.49% increase in mean 1RM values from pre-training testing to post-training testing. The comparison of mean 1RM values indicated that the participants' 1RM values were significantly higher post-training (M=42.73) than pre-training (M=31.54) (see Figure 3).

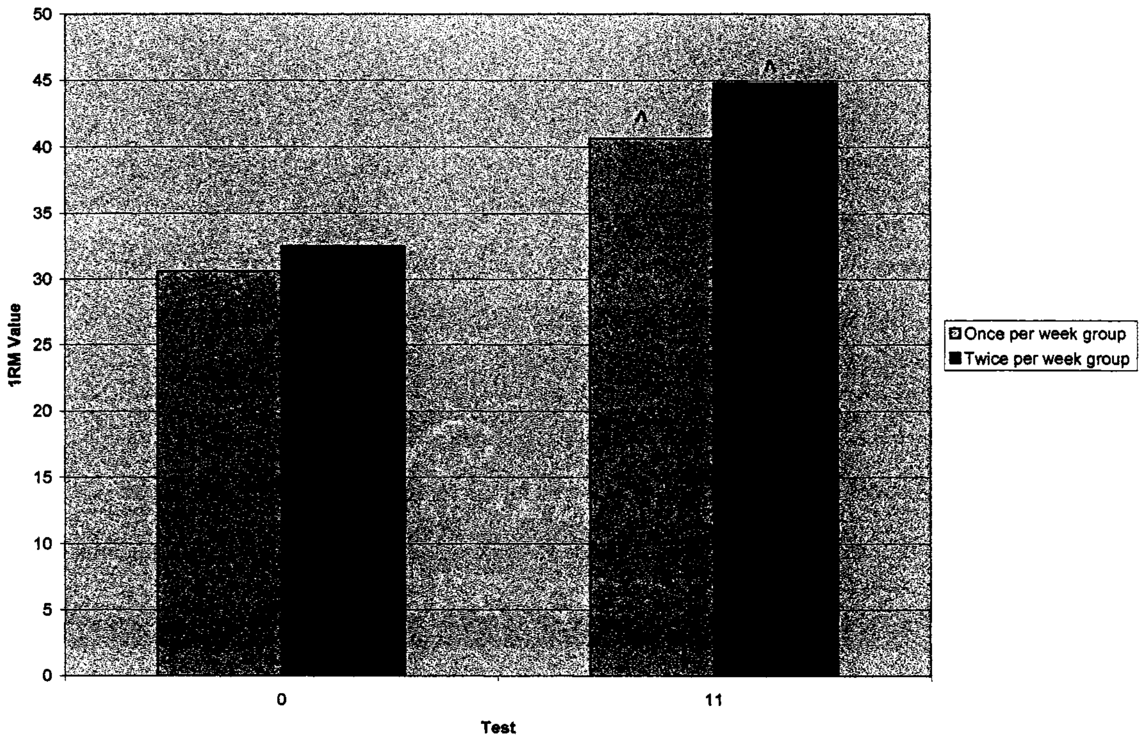

Figure 2. Dead lift 1RM values by testing and group
Note. ^=statistically significant difference compared to pre-test

Seated Row

There was no significant main effect for group F(1,24) = .87. There was no significant interaction between group and time, F(1,24) = 2.50. There was a significant main effect for time, F(1,24) = 52.85, p<.05. There was a 17.49% increase in mean 1RM values from pre-training testing to post-training testing. The comparison of mean 1RM values indicated that the participants' 1RM values were significantly higher post-training (M=21.86) than pre-training (M=18.60) (see Figure 4).

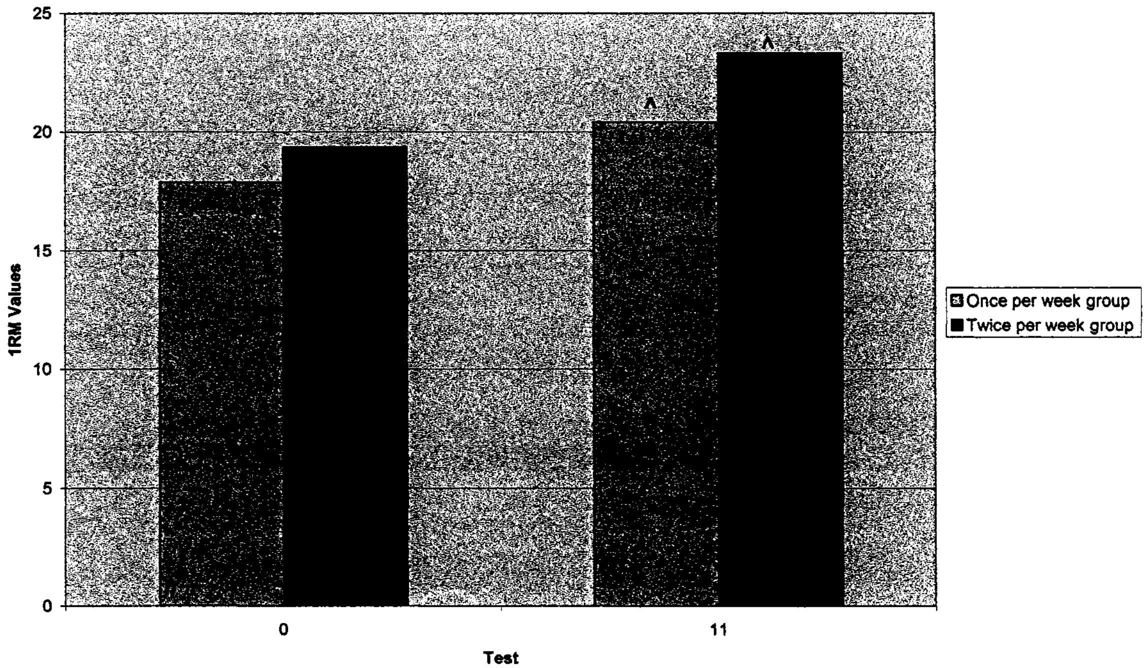

Figure 4. Seated row 1RM values by test and group
Note. ^=statistically significant difference compared to pre-test

Seated Dumbbell Curls

There was no significant main effect for group, $F(1,24) = 1.66$. There was no significant interaction between group and time, $F(1,24) = .22$. There was a significant main effect for time, $F(1,24) = 57.88$, $p<.05$. There was a 50.49% mean 1RM increase from the pre-training testing to post-training testing. The comparison of mean 1RM values showed that the participants' 1RM values post-training (M=6.77) were significantly higher than pre-training (M=4.50) (see Figure 5).

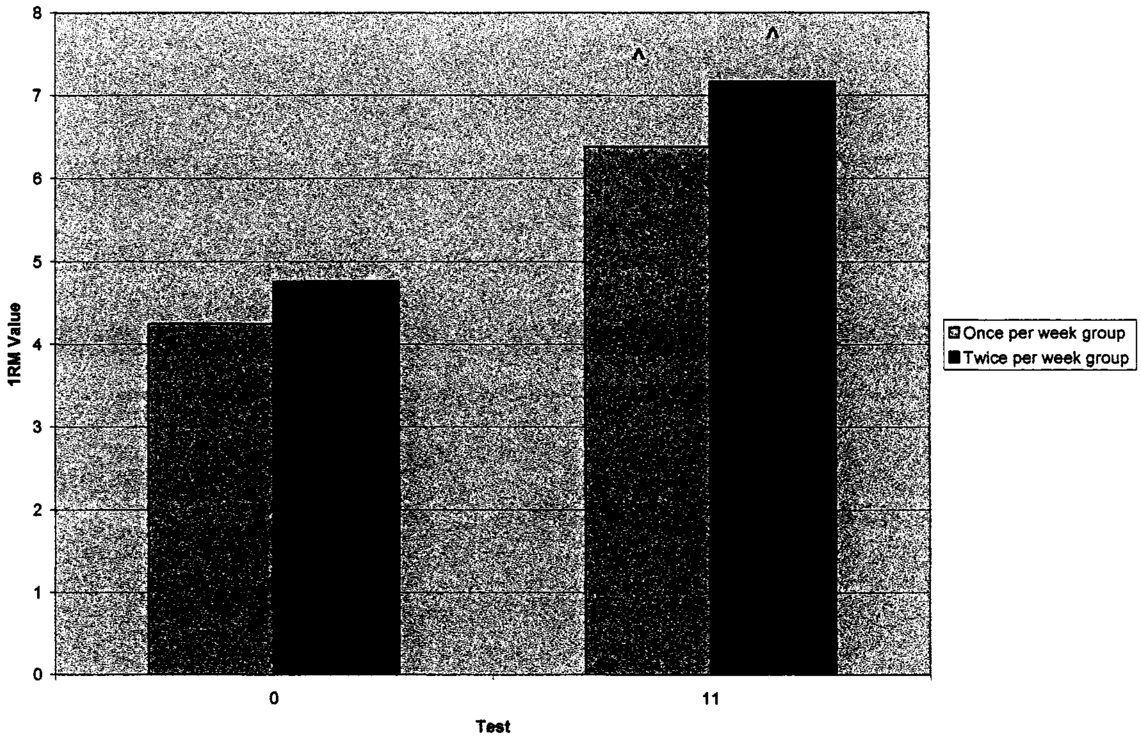

Figure 5. Seated dumbbell curl 1RM values by test and group
Note. ^=statistically significant difference compared to pre-test

Standing Military Press

There was no significant main effect for group, F(1,24) = 2.07. There was no significant interaction between group and time, F(1,24) = 1.71. There was a significant main effect for time, F(1,24) = 58.52, p<.05. There was a 43.23% increase in mean 1RM values between pre-training testing and post-training testing. The comparison of mean 1RM values showed that the participants' 1RM values post-training (M=7.12) were significantly higher than pre-training (M=4.97) (see Figure 6).

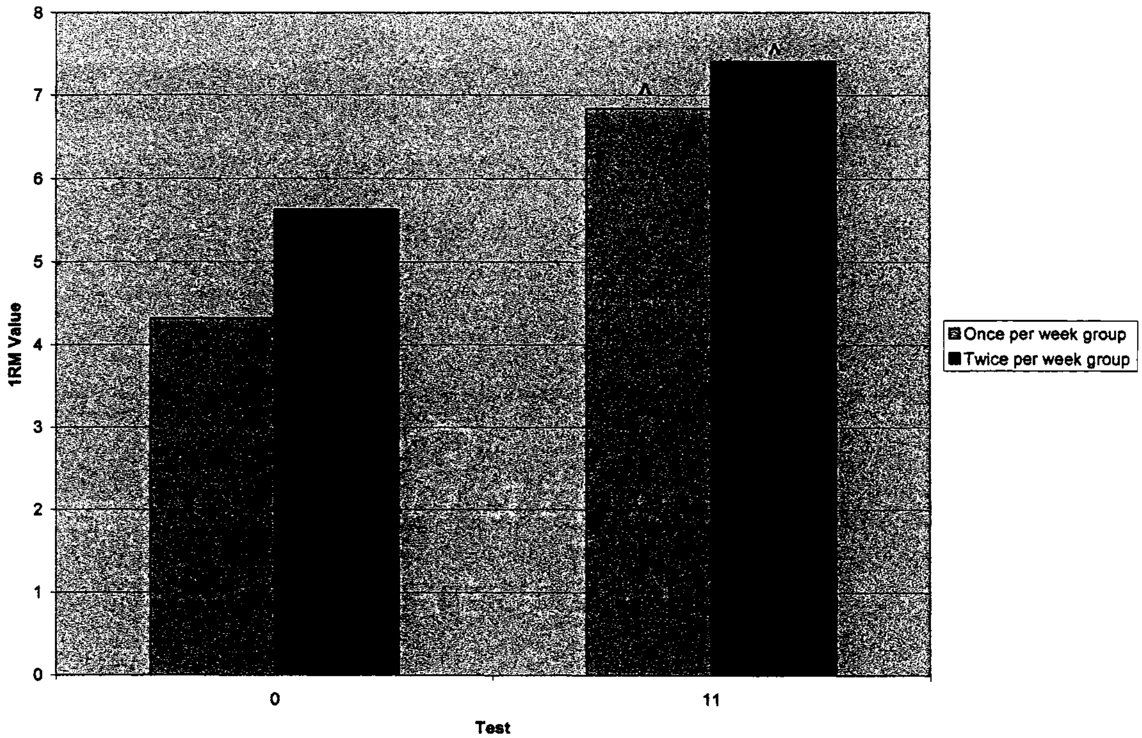

Figure 6. Standing military press mean 1RM values by test and group
Note. ^=statistically significant difference compared to pre-test

Chapter 5

Discussion

The following section provides a detailed discussion of the results and their relationship to each research hypothesis. It also includes future research ideas, practical applications, and concluding statements.

There was no significant difference between the groups, in any of the exercises performed, over the 10 week training period. This supports the null hypothesis that there would not be a statistically significant difference between training once per week and training twice per week utilizing a program designed with the same total training volume for both groups. Faigenbaum et al. (2002) determined that participants who trained twice per week experienced greater gains than those participants who trained once per week. They claimed that the greater gains in the twice per week group could be due to the difference in training volume. By controlling the training volume in the present study, this claim was substantiated and both groups yielded significant gains across the training period.

In the back squat and supine chest press exercise, participants were tested pre-training, training week 4, training week 7, and post-training. These representative intermittent tests were chosen to observe how the strength changes differed over time. In the back squat exercise, the greatest strength gains occurred during the first four weeks of the study (33.29%) with similar levels of strength gains occurring in the following 3 weeks (30.79%). Similarly, in the supine chest press exercise, the changes that occurred during the first seven weeks of the study (30.72%) were four times greater than those experienced during the last four weeks of the study (7.51%). The gains that occurred in both lifts towards the latter half of the study were less than those at the beginning, supporting previous research that has discussed how children have more difficulty increasing muscle mass than older age groups (Sale, 1989). Several researchers have discussed how neural and muscular adaptations are both responsible for increases in strength (Payne & Isaacs, 2005; Sale, 1989). Initial strength increases occur as a result of neural adaptation (Sale, 1988). It was concluded that current studies indicate that children may experience greater difficulty increasing muscle mass in comparison to older age groups. However, the neural adaptations that children encounter are similar or sometimes greater than older groups (Sale, 1989).

A confounding variable identified upon conclusion of the data collection for this study was that there was an unequal amount of time between the first 1RM test (pre-training) and the second 1RM test (week 4) in both the back squat and supine bench press when compared to the time between the second 1RM test (week4) and third 1RM test (week 7). This was identified as an error in the design of the testing format and could have affected the amount of strength changes that the participants demonstrated in these lifts. There was a statistical increase from pre-training (week 0) to week 4, and from week 7 to post-training (week 11) in the supine bench press, but there was not a significant difference from week 4 to week 7. There might have been a significant increase if 1RM testing had taken place at week 8 instead of week 7. Future researchers looking to replicate this study should conduct the same type of 1RM testing but should keep the number of training sessions between each 1RM testing session equal in order to keep the time between each participant's tests consistent.

Another confounding variable identified upon conclusion of the current study was that the participants were all allowed to continue with any regular physical activity (ie. team sports, recreational sports, physical education classes), as long as it didn't involve any other strength training (Faigenbaum et al., 2002). The allowance of continued physical activity could have affected the participants' ability to complete their weekly training sessions to the best of their ability. Future researchers looking to replicate this study should consider allowing no outside recreational activities, team sports, and or competitive physical activity during the data collection period. They should implement the same training methodology as this study but include a group that is restricted to only strength training and no outside physical activity (ie. team sports, recreational sports), to investigate the effects of outside activities on strength changes.

It is more difficult for untrained children to consciously activate the appropriate musculature during strength training than untrained adults (Sale, 1989). Although the results of the current study indicated that if total training volume is the same, training once per week can yield similar strength gains as training twice per week, there is a high level of practical importance in training twice per week when beginning a strength training program. The greater the frequency of the training program, especially during the beginning weeks, there is a greater chance for the participant to learn the movement patterns, understand the appropriate breathing techniques, become familiar with training equipment, and develop a rapport with the training staff. However, some children do not have the luxury of large time commitments and/or the financial flexibility that twice-a-week training programs may require, therefore less frequent training programs might be more appealing and realistic.

The descriptive data in the current study indicates that working out twice per week may result in greater strength gains than working out once per week. The absolute mean 1RM values for the twice per week group were greater overall in each lift, at each time of testing, when compared to the once per week group. This may have been statistically significant if there had been a larger sample size.

Other studies have reported significant gains in strength by children in response to training twice per week, (Faigenbaum et al., 1993; Faigenbaum et al., 1996b; Faigenbaum et al., 1999; Faigenbaum et al., 2001; Faigenbaum et al., 2002; Flanagan et al., 2001) and thrice per week (Pfeiffer et al., 1986; Ramsay et al., 1990; Rians et al., 1987; Sothern et al., 2000; Weltman et al., 1986). One study investigated the effects of training once per week (Faigenbaum et al., 2002) and reported significant strength gains as a result of training once per week. The results of the current study are significant because they add to this body of research.

Future research could further investigate the effects of frequency. The effects of greater training volumes could be studied to observe how the magnitude of total training volume affects increases in strength, as well as participant attendance and enjoyment levels.

Based on personal observation and participation by the researcher, in select cases, the 1RM values may not be the "best" indicator of changes in muscular strength.

Because of the learning effect, an increase in comfort with the movement patterns, and the environment, participant lifting form changes were seen, but they may not necessarily have resulted in increased loads lifted and recorded. This may have occurred because select participants were strong enough to lift a baseline amount of weight with incorrect form, but were held back from increasing weight until they were able to lift it safely, with proper technique. Therefore, it may be possible that some of the participants' changes in strength are not true representations of their strength gains. Future research may investigate similar frequency and training volumes as the current study, but measure strength gains by using both 1RM values and measuring the cross-sectional area of the muscle. The use of this method would provide further insight on the changes in muscle mass, if any, that occur in children that participate in strength changes. No study to date has investigated the effects of frequency on strength training in children on the size increase of a selected muscle or muscle group.

A future study should explain the use of both quantitative data (ie. 1RM values) and qualitative data (ie. video-taping and observation of form changes) to report strength gains. The use of a biomechanics digitizing program might also prove useful in tracking form changes in conjunction with strength changes over the training period.

Finally, future studies should consider a longitudinal approach to observe the effects of time on strength gains as well as a periodized program in children. These studies could follow a group of children from a young age (i.e., 7 years old) over their pre-pubescent years and through adolescence to compare the effects of strength training while pre-pubescent with those experienced as an adolescent. This could provide further knowledge regarding the neural and muscular adaptations that occur in children, as well as if hypertrophy occurs past a certain point in the time of training.

This same type of study may be explored in a periodized format. Periodization is the process of structuring training into phases. Each phase of the training program vary's in intensity and total training volume (Fleck & Kraemer, 1996). In a longitudinal study, there would be enough time throughout the study (i.e., months and years) to implement phases of training for each participant. While these principles can be adopted for short-term training program studies, the effects can be better seen in a longitudinal training study.

Concluding Remarks

In conclusion, the results from this investigation indicate that if untrained children begin a strength training program once per week with two sets of 12-15 repetitions or twice per week with one set of 12-15 repetitions on each day, significant strength gains do occur. These findings are consistent with the current recommendations from the American Academy of Pediatrics (2001), the American College of Sports Medicine (2000), and the National Strength and Conditioning Association (Faigenbaum et al., 1996a).

Based on the statistical data from the current study, it has been shown that there is no difference in training once per week versus twice per week. In recommending the optimal training frequency, the researcher believes it to be case specific. Each individual enters strength training programs under varying circumstances, with different needs, and different limitations. Therefore, the researcher believes that the most important factor to consider is how to get each individual habitually active in a program that is comfortable for them.

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APPENDIX A

AGE OF MENARCHE QUESTIONNAIRE

Appendix A
Age of Menarche Questionnaire
(adopted from Beunen, G., deBeul, G., Ostyn, M., Renson, R., Simons, J., and vanGerven, D.1978)

Instructions: Please sit down with your daughter and answer these questions. If the answer to the first question is no, it is your decision to discuss the meaning of the word with your daughter. If you are uncomfortable with this discussion, you may write "decline to answer".

1. Do you know what menstruation means?

2. Have you already menstruated?

3. Can you remember the exact date of your first menstruation?

APPENDIX B

PARENT/GUARDIAN CONSENT FORM

Consent From – Parent/Legal Guardian
Agreement to Participate in Research
Responsible Investigator: Analisa F. Naldi (SJSU Graduate Student)
Title of Protocol: Effects of frequency of strength training in prepubescent girls.

1. Your child or ward has been asked to participate in a research study investigating the effects of training frequency on strength changes in healthy, untrained prepubescent girls.
2. Your child or ward will be asked to consistently attend one or two strength training sessions (depending on which group they are randomly assigned to), approximately 60 minutes in duration, for 10 weeks. The will be asked to perform seven weight training exercises, (back squat, dead lift, supine bench press, calf raise, seated row, seated dumbbell curls, and standing military press) during each strength training session. The study will take place at FIT (Focused Individualized Training), located at 600 Rancho Shopping Center, Los Altos, CA.
3. Potential risks of participation in the study will include dropping a weighted barbell, dumbbell, or plate on themselves. This risk will be minimized with a coach: participant ratio of 1:1 on the back squat, dead lift, supine bench press, and standing military press. These exercises all pose the risk of dropping a weight on themselves if improperly attempted; therefore each participant will have an individual spotter while completing the lift.

Another potential risk of strength training is straining a muscle. The risk will be minimized by the appropriate supervision of a certified strength and conditioning staff, including a minimum of 1 coach per 5 participants.

4. Direct benefits from participation in the strength training program may include but are not limited to strength gains, increased knowledge about weight training exercises, and increased knowledge about muscle groups. A possible indirect benefit may be general feelings of reward from being of help to a research project.
5. Each child and parent/legal guardian will be asked to complete a questionnaire which addresses age of menarche. If this issue is uncomfortable for discussion, the child and/or parent may choose "decline to answer". Questions regarding menstruation are required due to the requirement of every subject being prepubescent.
5. Although the results of this study may be published, no information that could identify your child or ward, your family, or you will be included.
6. No compensation will be awarded for participation in the study.
7. Questions about this research may be addressed to Analisa F. Naldi, 650-743-2310. Complaints about the research may be presented to Dr. James Kao, Ph.D., Department of Kinesiology, 408-924-3026. Questions about research subjects' rights or research-related injury may be presented to Pamela Stacks, Ph.D., Associate Vice President, Graduate Studies and Research, at (408) 924-2480.
9. No service of any kind, to which you and/or your child/ward are otherwise entitled, will be lost or jeopardized if you choose to "not participate" in the study.

Initial__________

10. Your consent for your child or ward to participate is being given voluntarily. You may refuse to allow his or her participation in the entire study or in any part of the study. If you allow his or her participation, you are free to withdraw your child or ward from the study at any time, without any negative effect on your relations with San Jose State University or with any other participating institutions or agencies.

11. At the time that you sign this consent form, you will receive a copy of it for your records, signed and dated by the investigator.

--The signature of a parent or legal guardian on this document indicates:
a) approval for the child or ward to participate in the study,
b) that the child is freely willing to participate, and
c) that the child is permitted to decline to participate, in all or part of the study, at any point.

-- The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject's parent or guardian has been fully informed of the subject's rights.

____

Name of Child or Ward

____

Parent or Guardian Signature Date

____

Relationship to Child or Ward

____

Full Mailing Address

____

Investigator's Signature Date

____

Investigator's Signature

____

APPENDIX C

CHILD/PARTICIPANT CONSENT FORM

Consent Form – ParticipantAgreement to Participate in Research
Responsible Investigator: Analisa F. Naldi (SJSU Graduate Student)
Title of Protocol: Effects of frequency of strength training in prepubescent girls.

You are being asked to participate in a study investigating the effects of frequency of strength training in prepubescent girls. You will be asked to workout either one or two times each week for the next 10 weeks and to use your best effort possible every time you workout. You will learn how to perform seven weight training exercises, (back squat, dead lift, supping bench press, calf raise, seated row, seated dumbbell curls, and standing military press), which will target all of the major muscle groups in your body. You will be working out at FIT (Focused Individualized Training), located at 600 Rancho Shopping Center.

You will be at risk of dropping a weighted barbell, dumbbell, or plate on yourself if you do not pay attention to performing each exercise correctly. Another potential risk of strength training is straining a muscle. You must pay attention to each exercise as you are doing it and ask questions to your coach if you don't understand something.

Due to participation in the strength training program you may get stronger. You will also gain knowledge about weight training exercises, and increased knowledge about muscle groups.

You will be asked to complete a questionnaire with your parent/legal guardian before participating in the study. Should you and your parent/legal guardian choose to "decline to answer," you will not be asked to participate in the study.

Your consent for yourself to participate is being given voluntarily. You may refuse to participate in the entire study or in any part of the study. If you decide to participate, you are free to withdraw from the study at any time, without any negative effect on your relations with San Jose State University or with any other participating institutions or agencies. This is a decision that both you and your parents will make together.

--Your signature on this document indicates:
a) agreement for the child or ward to participate in the study,
b) that the child is freely willing to participate, and
c) that the child is permitted to decline to participate, in all or part of the study, at any point.

-- The signature of a researcher on this document indicates agreement to include the above named subject in the research and attestation that the subject's parent or guardian has been fully informed of the subject's rights.

______________________________Child Name______________Date
________________Investigator's Signature Date
____Investigator's Signature

APPENDIX D

1RM MEASUREMENT INSTRUCTIONS

Strength Measurement Instructions

(1RM Tests)

During our first strength training session you will each be assigned to work with a partner. You will have the same partner during our entire 8 weeks of training. You and your partner will be performing a 1 repetition maximum test. You will lift as much weight as you can 1 time, maintaining proper form. If the weight is too light and you can lift more than 1 repetition, we will increase the weight slightly, until you can lift it no more than 1 time correctly. This will be your starting weight for each exercise.

Remember to watch your partner and make sure that they are exhaling (breathing out) when they are working the hardest during each lift. For example, on the supine bench press, when you are pushing up and away with your arms, you're working against the weight, therefore you're working harder. So, you will exhale when you push out and inhale on your way back down to the position where you started.

It is most important for you to all remember to do your best on every exercise you do. This is important because the results of your training will help all of you and future children who want to strength train. It is also important for you to encourage your partner, be aware of what you are doing, what is going on around you, and act responsibly. If you don't understand something, please be sure to ask at *any* time. And, have fun when you're training. Are there any questions? (Repeat if necessary).

APPENDIX E

1 RM MEASUREMENT DATA COLLECTION

NAME: GROUP #: 1RM TEST DATE: P #

	6 REPS	3 REPS	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1RM
B SQUAT										
DEADLIFT										
BENCH PRESS										
S. CALF RAISE										
SEATED ROW										
S. DB CURL										
MILITARY PRESS										

NAME: GROUP #: 1RM TEST DATE: P #

	6 REPS	3 REPS	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1RM
B SQUAT										
BENCH PRESS										

NAME: GROUP #: 1RM TEST DATE: P #

	6 REPS	3 REPS	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1RM
B SQUAT										
BENCH PRESS										

NAME: GROUP #: 1RM TEST DATE: P #

	6 REPS	3 REPS	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1 REP	1RM
B SQUAT										
DEADLIFT										
BENCH PRESS										
S. CALF RAISE										
SEATED ROW										
S. DB CURL										
MILITARY PRESS										

APPENDIX F

STRENGTH TRAINING LOG

2 X WEEK TRAINING GROUP

Week ___	Set 1 – D1	Set 1 – D2	**NOTES**
Back Squat	___Reps ___Wt.	___Reps ___Wt.	
Dead Lifts	___Reps ___Wt.	___Reps ___Wt.	
Seated Calf Raise	___Reps ___Wt.	___Reps ___Wt.	
Supine Chest Press	___Reps ___Wt.	___Reps ___Wt.	
Seated Row	___Reps ___Wt.	___Reps ___Wt.	
Seated Dumbbell Curls	___Reps ___Wt.	___Reps ___Wt.	
Standing Military Press	___Reps ___Wt.	___Reps ___Wt.	

Participant Number ____________________
Age________________ **Group**____________
Additional
Comments____
____
____
____
____

APPENDIX G

STRENGTH TRAINING LOG

1 X WEEK TRAINING GROUP

WEEK	SET 1	SET 2	NOTES
BACK SQUAT	___REPS ___WEIGHT	___REPS ___WEIGHT	
DEAD LIFT	___REPS ___WEIGHT	___REPS ___WEIGHT	
SEATED CALF RAISE	___REPS ___WEIGHT	___REPS ___WEIGHT	
SUPINE CHEST PRESS	___REPS ___WEIGHT	___REPS ___WEIGHT	
SEATED ROW	___REPS ___WEIGHT	___REPS ___WEIGHT	
SEATED DUMBBELL CURLS	___REPS ___WEIGHT	___REPS ___WEIGHT	
STANDING MILITARY PRESS	___REPS ___WEIGHT	___REPS ___WEIGHT	

Participant Number ____________________
Age_______________ **Group**____________
Additional
Comments____
____
____
____
____

APPENDIX H

SPSS STATISTICAL ANALYSES

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

time	Dependent Variable
1	BSQ
2	BSQ2
3	BSQ3
4	BSQ4

Between-Subjects Factors

		N
Group	1	13
	2	13

Descriptive Statistics

	Group	Mean	Std. Deviation	N
BSQ	1	17.9754	8.57082	13
	2	21.3846	9.84284	13
	Total	19.6800	9.20789	26
BSQ2	1	24.6538	8.20667	13
	2	27.8077	9.49460	13
	Total	26.2308	8.84221	26
BSQ3	1	31.7692	10.84861	13
	2	36.8462	11.46441	13
	Total	34.3077	11.23751	26
BSQ4	1	34.8077	11.51003	13
	2	39.8846	11.26232	13
	Total	37.3462	11.45318	26

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
time	Pillai's Trace	.833	36.709[a]	3.000	22.000
	Wilks' Lambda	.167	36.709[a]	3.000	22.000
	Hotelling's Trace	5.006	36.709[a]	3.000	22.000
	Roy's Largest Root	5.006	36.709[a]	3.000	22.000
time * Group	Pillai's Trace	.022	.164[a]	3.000	22.000
	Wilks' Lambda	.978	.164[a]	3.000	22.000
	Hotelling's Trace	.022	.164[a]	3.000	22.000
	Roy's Largest Root	.022	.164[a]	3.000	22.000

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
time	Pillai's Trace	.000	.833
	Wilks' Lambda	.000	.833
	Hotelling's Trace	.000	.833
	Roy's Largest Root	.000	.833
time * Group	Pillai's Trace	.919	.022
	Wilks' Lambda	.919	.022
	Hotelling's Trace	.919	.022
	Roy's Largest Root	.919	.022

a. Exact statistic

b.
Design: Intercept+Group
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.374	22.336	5	.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse -Geisser	Huynh-Feldt	Lower-bound
time	.635	.717	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+Group
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square
time	Sphericity Assumed	4985.472	3	1661.824
	Greenhouse-Geisser	4985.472	1.904	2617.931
	Huynh-Feldt	4985.472	2.150	2318.453
	Lower-bound	4985.472	1.000	4985.472
time * Group	Sphericity Assumed	21.164	3	7.055
	Greenhouse-Geisser	21.164	1.904	11.114
	Huynh-Feldt	21.164	2.150	9.842
	Lower-bound	21.164	1.000	21.164
Error(time)	Sphericity Assumed	1954.970	72	27.152
	Greenhouse-Geisser	1954.970	45.705	42.774
	Huynh-Feldt	1954.970	51.608	37.881
	Lower-bound	1954.970	24.000	81.457

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		F	Sig.	Partial Eta Squared
time	Sphericity Assumed	61.204	.000	.718
	Greenhouse-Geisser	61.204	.000	.718
	Huynh-Feldt	61.204	.000	.718
	Lower-bound	61.204	.000	.718
time * Group	Sphericity Assumed	.260	.854	.011
	Greenhouse-Geisser	.260	.762	.011
	Huynh-Feldt	.260	.788	.011
	Lower-bound	.260	.615	.011
Error(time)	Sphericity Assumed			
	Greenhouse-Geisser			
	Huynh-Feldt			
	Lower-bound			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F
Intercept	89839.352	1	89839.352	266.836
Group	454.115	1	454.115	1.349
Error	8080.421	24	336.684	

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Sig.	Partial Eta Squared
Intercept	.000	.917
Group	.257	.053
Error		

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	27.302	2.545	22.050	32.553
2	31.481	2.545	26.229	36.732

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-4.179	3.599	.257
2	1	4.179	3.599	.257

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	-11.606	3.248
2	1	-3.248	11.606

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F
Contrast	113.529	1	113.529	1.349
Error	2020.105	24	84.171	

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Univariate Tests

Measure: MEASURE_1

	Sig.	Partial Eta Squared
Contrast	.257	.053
Error		

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

2. time

Estimates

Measure: MEASURE_1

time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	19.680	1.810	15.945	23.415
2	26.231	1.740	22.639	29.823
3	34.308	2.189	29.790	38.825
4	37.346	2.233	32.737	41.955

Pairwise Comparisons

Measure: MEASURE_1

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-6.551*	.953	.000
	3	-14.628*	1.391	.000
	4	-17.666*	1.949	.000
2	1	6.551*	.953	.000
	3	-8.077*	1.354	.000
	4	-11.115*	1.589	.000
3	1	14.628*	1.391	.000
	2	8.077*	1.354	.000
	4	-3.038*	1.236	.022
4	1	17.666*	1.949	.000
	2	11.115*	1.589	.000
	3	3.038*	1.236	.022

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

(I) time	(J) time	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	-8.519	-4.583
	3	-17.500	-11.756
	4	-21.690	-13.643
2	1	4.583	8.519
	3	-10.872	-5.281
	4	-14.394	-7.837
3	1	11.756	17.500
	2	5.281	10.872
	4	-5.590	-.487
4	1	13.643	21.690
	2	7.837	14.394
	3	.487	5.590

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

	Value	F	Hypothesis df	Error df
Pillai's trace	.833	36.709[a]	3.000	22.000
Wilks' lambda	.167	36.709[a]	3.000	22.000
Hotelling's trace	5.006	36.709[a]	3.000	22.000
Roy's largest root	5.006	36.709[a]	3.000	22.000

Each F tests the multivariate effect of time. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

Multivariate Tests

	Sig.	Partial Eta Squared
Pillai's trace	.000	.833
Wilks' lambda	.000	.833
Hotelling's trace	.000	.833
Roy's largest root	.000	.833

Each F tests the multivariate effect of time. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

3. Group * time

Measure: MEASURE_1

Group	time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	17.975	2.560	12.693	23.258
	2	24.654	2.461	19.574	29.734
	3	31.769	3.095	25.381	38.158
	4	34.808	3.158	28.290	41.326
2	1	21.385	2.560	16.102	26.667
	2	27.808	2.461	22.728	32.887
	3	36.846	3.095	30.457	43.235
	4	39.885	3.158	33.367	46.403

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

time	Dependent Variable
1	BP
2	BP2
3	BP3
4	BP4

Between-Subjects Factors

		N
Group	1	13
	2	13

Descriptive Statistics

	Group	Mean	Std. Deviation	N
BP	1	12.8147	4.44799	13
	2	15.9615	4.41806	13
	Total	14.3881	4.63039	26
BP2	1	17.3462	4.94716	13
	2	18.5000	5.10310	13
	Total	17.9231	4.95922	26
BP3	1	17.7692	4.90160	13
	2	19.8462	4.52486	13
	Total	18.8077	4.74147	26
BP4	1	18.5385	5.55076	13
	2	21.9000	4.88330	13
	Total	20.2192	5.40126	26

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
time	Pillai's Trace	.657	14.030[a]	3.000	22.000
	Wilks' Lambda	.343	14.030[a]	3.000	22.000
	Hotelling's Trace	1.913	14.030[a]	3.000	22.000
	Roy's Largest Root	1.913	14.030[a]	3.000	22.000
time * Group	Pillai's Trace	.197	1.797[a]	3.000	22.000
	Wilks' Lambda	.803	1.797[a]	3.000	22.000
	Hotelling's Trace	.245	1.797[a]	3.000	22.000
	Roy's Largest Root	.245	1.797[a]	3.000	22.000

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
time	Pillai's Trace	.000	.657
	Wilks' Lambda	.000	.657
	Hotelling's Trace	.000	.657
	Roy's Largest Root	.000	.657
time * Group	Pillai's Trace	.177	.197
	Wilks' Lambda	.177	.197
	Hotelling's Trace	.177	.197
	Roy's Largest Root	.177	.197

a. Exact statistic

b.
Design: Intercept+Group
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	.330	25.185	5	.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	.588	.657	.333

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+Group
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square
time	Sphericity Assumed	481.507	3	160.502
	Greenhouse-Geisser	481.507	1.763	273.084
	Huynh-Feldt	481.507	1.972	244.212
	Lower-bound	481.507	1.000	481.507
time * Group	Sphericity Assumed	20.376	3	6.792
	Greenhouse-Geisser	20.376	1.763	11.556
	Huynh-Feldt	20.376	1.972	10.334
	Lower-bound	20.376	1.000	20.376
Error(time)	Sphericity Assumed	454.984	72	6.319
	Greenhouse-Geisser	454.984	42.317	10.752
	Huynh-Feldt	454.984	47.320	9.615
	Lower-bound	454.984	24.000	18.958

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		F	Sig.	Partial Eta Squared
time	Sphericity Assumed	25.399	.000	.514
	Greenhouse-Geisser	25.399	.000	.514
	Huynh-Feldt	25.399	.000	.514
	Lower-bound	25.399	.000	.514
time * Group	Sphericity Assumed	1.075	.365	.043
	Greenhouse-Geisser	1.075	.343	.043
	Huynh-Feldt	1.075	.349	.043
	Lower-bound	1.075	.310	.043
Error(time)	Sphericity Assumed			
	Greenhouse-Geisser			
	Huynh-Feldt			
	Lower-bound			

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F
Intercept	33079.320	1	33079.320	437.957
Group	154.133	1	154.133	2.041
Error	1812.744	24	75.531	

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Sig.	Partial Eta Squared
Intercept	.000	.948
Group	.166	.078
Error		

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	16.617	1.205	14.130	19.105
2	19.052	1.205	16.565	21.539

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-2.435	1.704	.166
2	1	2.435	1.704	.166

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	-5.953	1.083
2	1	-1.083	5.953

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F
Contrast	38.533	1	38.533	2.041
Error	453.186	24	18.883	

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Univariate Tests

Measure: MEASURE_1

	Sig.	Partial Eta Squared
Contrast	.166	.078
Error		

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

2. time

Estimates

Measure: MEASURE_1

time	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	14.388	.869	12.594	16.182
2	17.923	.986	15.889	19.957
3	18.808	.925	16.898	20.717
4	20.219	1.025	18.103	22.335

Pairwise Comparisons

Measure: MEASURE_1

(I) time	(J) time	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-3.535*	.573	.000
	3	-4.420*	.792	.000
	4	-5.831*	.969	.000
2	1	3.535*	.573	.000
	3	-.885	.502	.091
	4	-2.296*	.733	.005
3	1	4.420*	.792	.000
	2	.885	.502	.091
	4	-1.412*	.483	.008
4	1	5.831*	.969	.000
	2	2.296*	.733	.005
	3	1.412*	.483	.008

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

(I) time	(J) time	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	-4.718	-2.352
	3	-6.053	-2.786
	4	-7.831	-3.831
2	1	2.352	4.718
	3	-1.920	.151
	4	-3.808	-.784
3	1	2.786	6.053
	2	-.151	1.920
	4	-2.409	-.414
4	1	3.831	7.831
	2	.784	3.808
	3	.414	2.409

Based on estimated marginal means

*. The mean difference is significant at the .05 level.

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Multivariate Tests

	Value	F	Hypothesis df	Error df
Pillai's trace	.657	14.030[a]	3.000	22.000
Wilks' lambda	.343	14.030[a]	3.000	22.000
Hotelling's trace	1.913	14.030[a]	3.000	22.000
Roy's largest root	1.913	14.030[a]	3.000	22.000

Each F tests the multivariate effect of time. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

Multivariate Tests

	Sig.	Partial Eta Squared
Pillai's trace	.000	.657
Wilks' lambda	.000	.657
Hotelling's trace	.000	.657
Roy's largest root	.000	.657

Each F tests the multivariate effect of time. These tests are based on the linearly independent pairwise comparisons among the estimated marginal means.

a. Exact statistic

3. Group * time

Measure: MEASURE_1

Group	time	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
1	1	12.815	1.230	10.277	15.352
	2	17.346	1.394	14.469	20.223
	3	17.769	1.308	15.069	20.469
	4	18.538	1.450	15.546	21.531
2	1	15.962	1.230	13.424	18.499
	2	18.500	1.394	15.623	21.377
	3	19.846	1.308	17.146	22.546
	4	21.900	1.450	18.908	24.892

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

time	Dependent Variable
1	DL
2	DL2

Between-Subjects Factors

		N
Group	1	13
	2	13

Descriptive Statistics

	Group	Mean	Std. Deviation	N
DL	1	30.5769	7.64811	13
	2	32.5000	10.25711	13
	Total	31.5385	8.91843	26
DL2	1	40.6538	11.23311	13
	2	44.8077	12.56075	13
	Total	42.7308	11.86527	26

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
time	Pillai's Trace	.649	44.370[a]	1.000	24.000
	Wilks' Lambda	.351	44.370[a]	1.000	24.000
	Hotelling's Trace	1.849	44.370[a]	1.000	24.000
	Roy's Largest Root	1.849	44.370[a]	1.000	24.000
time * Group	Pillai's Trace	.018	.441[a]	1.000	24.000
	Wilks' Lambda	.982	.441[a]	1.000	24.000
	Hotelling's Trace	.018	.441[a]	1.000	24.000
	Roy's Largest Root	.018	.441[a]	1.000	24.000

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
time	Pillai's Trace	.000	.649
	Wilks' Lambda	.000	.649
	Hotelling's Trace	.000	.649
	Roy's Largest Root	.000	.649
time * Group	Pillai's Trace	.513	.018
	Wilks' Lambda	.513	.018
	Hotelling's Trace	.513	.018
	Roy's Largest Root	.513	.018

a. Exact statistic

b.
Design: Intercept+Group
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+Group
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square
time	Sphericity Assumed	1628.481	1	1628.481
	Greenhouse-Geisser	1628.481	1.000	1628.481
	Huynh-Feldt	1628.481	1.000	1628.481
	Lower-bound	1628.481	1.000	1628.481
time * Group	Sphericity Assumed	16.173	1	16.173
	Greenhouse-Geisser	16.173	1.000	16.173
	Huynh-Feldt	16.173	1.000	16.173
	Lower-bound	16.173	1.000	16.173
Error(time)	Sphericity Assumed	880.846	24	36.702
	Greenhouse-Geisser	880.846	24.000	36.702
	Huynh-Feldt	880.846	24.000	36.702
	Lower-bound	880.846	24.000	36.702

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		F	Sig.	Partial Eta Squared
time	Sphericity Assumed	44.370	.000	.649
	Greenhouse-Geisser	44.370	.000	.649
	Huynh-Feldt	44.370	.000	.649
	Lower-bound	44.370	.000	.649
time * Group	Sphericity Assumed	.441	.513	.018
	Greenhouse-Geisser	.441	.513	.018
	Huynh-Feldt	.441	.513	.018
	Lower-bound	.441	.513	.018
Error(time)	Sphericity Assumed			
	Greenhouse-Geisser			
	Huynh-Feldt			
	Lower-bound			

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F
time	Linear	1628.481	1	1628.481	44.370
time * Group	Linear	16.173	1	16.173	.441
Error(time)	Linear	880.846	24	36.702	

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Sig.	Partial Eta Squared
time	Linear	.000	.649
time * Group	Linear	.513	.018
Error(time)	Linear		

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F
Intercept	71706.942	1	71706.942	383.200
Group	120.019	1	120.019	.641
Error	4491.038	24	187.127	

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Sig.	Partial Eta Squared
Intercept	.000	.941
Group	.431	.026
Error		

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	35.615	2.683	30.078	41.152
2	38.654	2.683	33.117	44.191

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-3.038	3.794	.431
2	1	3.038	3.794	.431

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	-10.869	4.792
2	1	-4.792	10.869

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F
Contrast	60.010	1	60.010	.641
Error	2245.519	24	93.563	

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Univariate Tests

Measure: MEASURE_1

	Sig.	Partial Eta Squared
Contrast	.431	.026
Error		

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

time	Dependent Variable
1	SR
2	SR2

Between-Subjects Factors

		N
Group	1	13
	2	13

Descriptive Statistics

	Group	Mean	Std. Deviation	N
SR	1	17.8601	6.77004	13
	2	19.3479	5.70792	13
	Total	18.6040	6.18176	26
SR2	1	20.4070	6.65002	13
	2	23.3091	5.08312	13
	Total	21.8580	5.98490	26

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
time	Pillai's Trace	.688	52.852[a]	1.000	24.000
	Wilks' Lambda	.312	52.852[a]	1.000	24.000
	Hotelling's Trace	2.202	52.852[a]	1.000	24.000
	Roy's Largest Root	2.202	52.852[a]	1.000	24.000
time * Group	Pillai's Trace	.094	2.496[a]	1.000	24.000
	Wilks' Lambda	.906	2.496[a]	1.000	24.000
	Hotelling's Trace	.104	2.496[a]	1.000	24.000
	Roy's Largest Root	.104	2.496[a]	1.000	24.000

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
time	Pillai's Trace	.000	.688
	Wilks' Lambda	.000	.688
	Hotelling's Trace	.000	.688
	Roy's Largest Root	.000	.688
time * Group	Pillai's Trace	.127	.094
	Wilks' Lambda	.127	.094
	Hotelling's Trace	.127	.094
	Roy's Largest Root	.127	.094

a. Exact statistic

b.
Design: Intercept+Group
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse -Geisser	Huynh-Feldt	Lower-bound
time	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+Group
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square
time	Sphericity Assumed	137.652	1	137.652
	Greenhouse-Geisser	137.652	1.000	137.652
	Huynh-Feldt	137.652	1.000	137.652
	Lower-bound	137.652	1.000	137.652
time * Group	Sphericity Assumed	6.501	1	6.501
	Greenhouse-Geisser	6.501	1.000	6.501
	Huynh-Feldt	6.501	1.000	6.501
	Lower-bound	6.501	1.000	6.501
Error(time)	Sphericity Assumed	62.508	24	2.604
	Greenhouse-Geisser	62.508	24.000	2.604
	Huynh-Feldt	62.508	24.000	2.604
	Lower-bound	62.508	24.000	2.604

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		F	Sig.	Partial Eta Squared
time	Sphericity Assumed	52.852	.000	.688
	Greenhouse-Geisser	52.852	.000	.688
	Huynh-Feldt	52.852	.000	.688
	Lower-bound	52.852	.000	.688
time * Group	Sphericity Assumed	2.496	.127	.094
	Greenhouse-Geisser	2.496	.127	.094
	Huynh-Feldt	2.496	.127	.094
	Lower-bound	2.496	.127	.094
Error(time)	Sphericity Assumed			
	Greenhouse-Geisser			
	Huynh-Feldt			
	Lower-bound			

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F
time	Linear	137.652	1	137.652	52.852
time * Group	Linear	6.501	1	6.501	2.496
Error(time)	Linear	62.508	24	2.604	

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Sig.	Partial Eta Squared
time	Linear	.000	.688
time * Group	Linear	.127	.094
Error(time)	Linear		

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F
Intercept	21283.321	1	21283.321	297.117
Group	62.630	1	62.630	.874
Error	1719.190	24	71.633	

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Sig.	Partial Eta Squared
Intercept	.000	.925
Group	.359	.035
Error		

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	19.134	1.660	15.708	22.559
2	21.328	1.660	17.903	24.754

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-2.195	2.347	.359
2	1	2.195	2.347	.359

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	-7.040	2.650
2	1	-2.650	7.040

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F
Contrast	31.315	1	31.315	.874
Error	859.595	24	35.816	

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Univariate Tests

Measure: MEASURE_1

	Sig.	Partial Eta Squared
Contrast	.359	.035
Error		

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

time	Dependent Variable
1	DBC
2	DBC2

Between-Subjects Factors

		N
Group	1	13
	2	13

Descriptive Statistics

	Group	Mean	Std. Deviation	N
DBC	1	4.2483	.88697	13
	2	4.7552	1.10744	13
	Total	4.5017	1.01643	26
DBC2	1	6.3811	1.95829	13
	2	7.1678	1.73735	13
	Total	6.7745	1.85755	26

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
time	Pillai's Trace	.707	57.877[a]	1.000	24.000
	Wilks' Lambda	.293	57.877[a]	1.000	24.000
	Hotelling's Trace	2.412	57.877[a]	1.000	24.000
	Roy's Largest Root	2.412	57.877[a]	1.000	24.000
time * Group	Pillai's Trace	.009	.219[a]	1.000	24.000
	Wilks' Lambda	.991	.219[a]	1.000	24.000
	Hotelling's Trace	.009	.219[a]	1.000	24.000
	Roy's Largest Root	.009	.219[a]	1.000	24.000

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
time	Pillai's Trace	.000	.707
	Wilks' Lambda	.000	.707
	Hotelling's Trace	.000	.707
	Roy's Largest Root	.000	.707
time * Group	Pillai's Trace	.644	.009
	Wilks' Lambda	.644	.009
	Hotelling's Trace	.644	.009
	Roy's Largest Root	.644	.009

a. Exact statistic

b.
Design: Intercept+Group
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse -Geisser	Huynh-Feldt	Lower-bound
time	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+Group
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square
time	Sphericity Assumed	67.149	1	67.149
	Greenhouse-Geisser	67.149	1.000	67.149
	Huynh-Feldt	67.149	1.000	67.149
	Lower-bound	67.149	1.000	67.149
time * Group	Sphericity Assumed	.254	1	.254
	Greenhouse-Geisser	.254	1.000	.254
	Huynh-Feldt	.254	1.000	.254
	Lower-bound	.254	1.000	.254
Error(time)	Sphericity Assumed	27.845	24	1.160
	Greenhouse-Geisser	27.845	24.000	1.160
	Huynh-Feldt	27.845	24.000	1.160
	Lower-bound	27.845	24.000	1.160

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		F	Sig.	Partial Eta Squared
time	Sphericity Assumed	57.877	.000	.707
	Greenhouse-Geisser	57.877	.000	.707
	Huynh-Feldt	57.877	.000	.707
	Lower-bound	57.877	.000	.707
time * Group	Sphericity Assumed	.219	.644	.009
	Greenhouse-Geisser	.219	.644	.009
	Huynh-Feldt	.219	.644	.009
	Lower-bound	.219	.644	.009
Error(time)	Sphericity Assumed			
	Greenhouse-Geisser			
	Huynh-Feldt			
	Lower-bound			

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F
time	Linear	67.149	1	67.149	57.877
time * Group	Linear	.254	1	.254	.219
Error(time)	Linear	27.845	24	1.160	

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Sig.	Partial Eta Squared
time	Linear	.000	.707
time * Group	Linear	.644	.009
Error(time)	Linear		

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F
Intercept	1652.992	1	1652.992	505.038
Group	5.439	1	5.439	1.662
Error	78.552	24	3.273	

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Sig.	Partial Eta Squared
Intercept	.000	.955
Group	.210	.065
Error		

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	5.315	.355	4.582	6.047
2	5.962	.355	5.229	6.694

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-.647	.502	.210
2	1	.647	.502	.210

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

		95% Confidence Interval for Difference[a]	
(I) Group	(J) Group	Lower Bound	Upper Bound
1	2	-1.682	.389
2	1	-.389	1.682

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F
Contrast	2.720	1	2.720	1.662
Error	39.276	24	1.637	

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Univariate Tests

Measure: MEASURE_1

	Sig.	Partial Eta Squared
Contrast	.210	.065
Error		

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

General Linear Model

Within-Subjects Factors

Measure: MEASURE_1

time	Dependent Variable
1	MP
2	MP2

Between-Subjects Factors

		N
Group	1	13
	2	13

Descriptive Statistics

	Group	Mean	Std. Deviation	N
MP	1	4.3182	1.54701	13
	2	5.6294	1.41675	13
	Total	4.9738	1.59975	26
MP2	1	6.8357	2.09424	13
	2	7.4126	2.10465	13
	Total	7.1241	2.07797	26

Multivariate Tests[b]

Effect		Value	F	Hypothesis df	Error df
time	Pillai's Trace	.709	58.517[a]	1.000	24.000
	Wilks' Lambda	.291	58.517[a]	1.000	24.000
	Hotelling's Trace	2.438	58.517[a]	1.000	24.000
	Roy's Largest Root	2.438	58.517[a]	1.000	24.000
time * Group	Pillai's Trace	.066	1.706[a]	1.000	24.000
	Wilks' Lambda	.934	1.706[a]	1.000	24.000
	Hotelling's Trace	.071	1.706[a]	1.000	24.000
	Roy's Largest Root	.071	1.706[a]	1.000	24.000

Multivariate Tests[b]

Effect		Sig.	Partial Eta Squared
time	Pillai's Trace	.000	.709
	Wilks' Lambda	.000	.709
	Hotelling's Trace	.000	.709
	Roy's Largest Root	.000	.709
time * Group	Pillai's Trace	.204	.066
	Wilks' Lambda	.204	.066
	Hotelling's Trace	.204	.066
	Roy's Largest Root	.204	.066

a. Exact statistic

b.
Design: Intercept+Group
Within Subjects Design: time

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.
time	1.000	.000	0	.

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

Mauchly's Test of Sphericity[b]

Measure: MEASURE_1

Within Subjects Effect	Epsilon[a]		
	Greenhouse-Geisser	Huynh-Feldt	Lower-bound
time	1.000	1.000	1.000

Tests the null hypothesis that the error covariance matrix of the orthonormalized transformed dependent variables is proportional to an identity matrix.

a. May be used to adjust the degrees of freedom for the averaged tests of significance. Corrected tests are displayed in the Tests of Within-Subjects Effects table.

b.
Design: Intercept+Group
Within Subjects Design: time

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		Type III Sum of Squares	df	Mean Square
time	Sphericity Assumed	60.112	1	60.112
	Greenhouse-Geisser	60.112	1.000	60.112
	Huynh-Feldt	60.112	1.000	60.112
	Lower-bound	60.112	1.000	60.112
time * Group	Sphericity Assumed	1.752	1	1.752
	Greenhouse-Geisser	1.752	1.000	1.752
	Huynh-Feldt	1.752	1.000	1.752
	Lower-bound	1.752	1.000	1.752
Error(time)	Sphericity Assumed	24.654	24	1.027
	Greenhouse-Geisser	24.654	24.000	1.027
	Huynh-Feldt	24.654	24.000	1.027
	Lower-bound	24.654	24.000	1.027

Tests of Within-Subjects Effects

Measure: MEASURE_1

Source		F	Sig.	Partial Eta Squared
time	Sphericity Assumed	58.517	.000	.709
	Greenhouse-Geisser	58.517	.000	.709
	Huynh-Feldt	58.517	.000	.709
	Lower-bound	58.517	.000	.709
time * Group	Sphericity Assumed	1.706	.204	.066
	Greenhouse-Geisser	1.706	.204	.066
	Huynh-Feldt	1.706	.204	.066
	Lower-bound	1.706	.204	.066
Error(time)	Sphericity Assumed			
	Greenhouse-Geisser			
	Huynh-Feldt			
	Lower-bound			

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Type III Sum of Squares	df	Mean Square	F
time	Linear	60.112	1	60.112	58.517
time * Group	Linear	1.752	1	1.752	1.706
Error(time)	Linear	24.654	24	1.027	

Tests of Within-Subjects Contrasts

Measure: MEASURE_1

Source	time	Sig.	Partial Eta Squared
time	Linear	.000	.709
time * Group	Linear	.204	.066
Error(time)	Linear		

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Type III Sum of Squares	df	Mean Square	F
Intercept	1902.670	1	1902.670	340.940
Group	11.586	1	11.586	2.076
Error	133.936	24	5.581	

Tests of Between-Subjects Effects

Measure: MEASURE_1
Transformed Variable: Average

Source	Sig.	Partial Eta Squared
Intercept	.000	.934
Group	.163	.080
Error		

Estimated Marginal Means

1. Group

Estimates

Measure: MEASURE_1

Group	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
1	5.577	.463	4.621	6.533
2	6.521	.463	5.565	7.477

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.[a]
1	2	-.944	.655	.163
2	1	.944	.655	.163

Based on estimated marginal means

Pairwise Comparisons

Measure: MEASURE_1

(I) Group	(J) Group	95% Confidence Interval for Difference[a] Lower Bound	Upper Bound
1	2	-2.296	.408
2	1	-.408	2.296

Based on estimated marginal means

a. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

Univariate Tests

Measure: MEASURE_1

	Sum of Squares	df	Mean Square	F
Contrast	5.793	1	5.793	2.076
Error	66.968	24	2.790	

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.

Univariate Tests

Measure: MEASURE_1

	Sig.	Partial Eta Squared
Contrast	.163	.080
Error		

The F tests the effect of Group. This test is based on the linearly independent pairwise comparisons among the estimated marginal means.